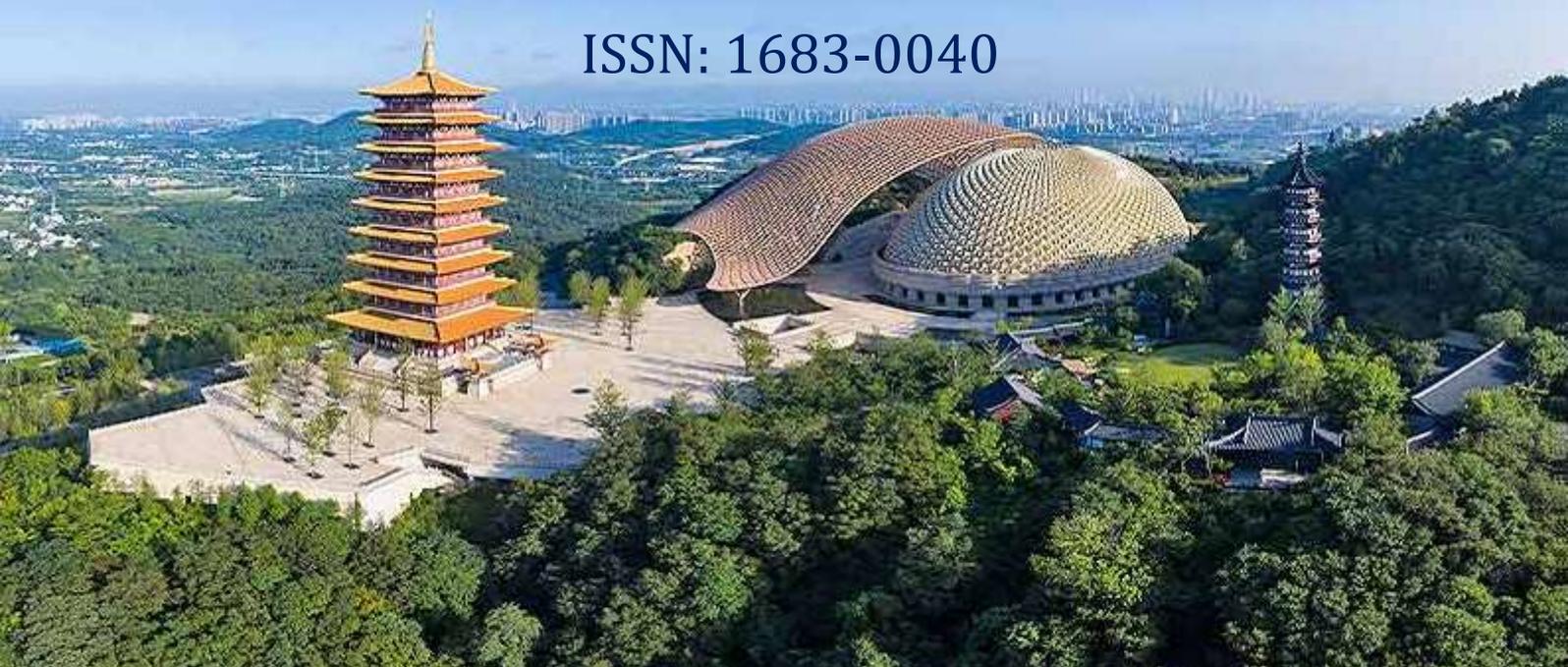




# Proceedings of The International Conference on Electronic Business *Volume 21*

Edited by  
**Eldon Y. Li**  
**Haiwei Zhou**  
**Benjamin Yen**

ICEB'21  
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International Conference on  
Electronic Business  
*Volume 21***

*“Corporate Resilience through Electronic Business in the Post-COVID Era”*

Edited by

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# PREFACE

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Welcome to the 21st International Conference on Electronic Business (ICEB 2021) hybrid conference. Celebrating its 21st anniversary, the ICEB is held this year virtually again by the University of Hong Kong Business School and physically by the Hohai University Business School in Nanjing, China. The theme of this year's Conference is "Corporate Resilience through Electronic Business in the Post-COVID Era." We received 93 submissions and 78 papers were accepted into the final program that consisted of 26 sessions. The topic areas of the papers include artificial intelligence, big data, blockchain, COVID-19 issues, digital marketing, E-adoption, E-commerce, E-education, E-innovation, E-SCM, E-sustainability, healthcare issues, IoT, smart home, smart technologies, social commerce, technological issues, and user and consumer behaviors, etc. In this proceedings book, we have included 56 full papers and 13 work-in-progress papers. Among full papers, 3 received the "Best Paper Awards," and 5 received the "Outstanding Paper Awards." These papers were reviewed and selected by the Best Paper Awards Committee, consisting of six members: Prof. Chih-Ping Wei (National Taiwan University, Taiwan), Prof. Ibrahim M. Al-Jabri (King Fahd University of Petroleum and Minerals, Saudi Arabia), Prof. Ravi Sharma (Zayed University, Abu Dhabi, U.A.E.), Prof. Savvas Papagiannidis (Newcastle University, Newcastle upon Tyne, U.K.), Prof. Stuart Orr (Deakin Business School, Australia), and Prof. Thurasamy Ramayah (Universiti Sains Malaysia, Penang, Malaysia).



In the conference, we have scheduled three keynote speakers (in sequence of appearance): Prof. Chris Westland, the Chief Editor of Electronic Commerce Research. Prof. Patrick Y.K. Chau, the Chief Editor of Information and Management; and Prof. Christy Cheung, the Chief Editor of Internet Research. Because of the COVID-19 pandemic, all keynote speeches and presentations are delivered with the ZOOM software in two virtual meeting rooms. The keynote speeches this year are scheduled in two days considering the time zone differences of the speakers in the U.S. Presentation sessions are also scheduled in a way that authors on the other continents can attend the meetings between 9 AM and 9 PM time frame.



The annual conference of ICEB is an excellent opportunity for the scholars like you and me to share research ideas and get informed about the latest development in the fields. We could meet leading scholars from around the world to establish a research network and engage in future collaborations. In this conference, there are 79 registered scholars from 18 countries or regions, including Australia, China, Finland, Hong Kong, India, Indonesia, Iran, Malaysia, Morocco, New Zealand, Saudi Arabia, South Africa, Spain, Sri Lanka, Taiwan, Thailand, UAE, UK, USA. This year, the Best Paper Award Committee consisting of six members had selected three best-quality papers and five outstanding papers to receive the awards.

Finally, on behalf of the entire Conference Committee, we thank you all very much for participating in

ICEB 2021 hybrid conference, without your presence the conference cannot be successful. We also thank all the speakers, presenters, reviewers, the program committee members, Best Paper Award committee members, and session chairs, who all have contributed their time and effort to this conference. Special thanks go to our conference secretariat, Prof. Benjamin Yen and his conference team from the University of Hong Kong, who had provided the administrative and technical support to execute the ZOOM conference events tirelessly and flawlessly. Also, to our Treasurer, Dr. Honglei Li, and her team at Northumbria University, we thank them manage the payment gateway effectively. Finally, we thank you all for preparing and sharing your research findings in the meetings and look forward to seeing you again in ICEB 2022 at Thammasat University in Bangkok, Thailand.



Sincerely yours,

*Eldon Y. Li*

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## A Model on Energy Power Management of Air-Recirculation in a Clean Room

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### ABSTRACT

With the rapid development of intelligent networking technology, fan filter units (FFUs) in cleanrooms can be networked as a cluster to form multiple low-pollution minienvironments. Therefore, FFU cluster management for different process cleanliness requirements and energy savings targets is a critical topic. This study uses particle swarm optimization with a metaheuristics algorithm to collect, calculate, and dynamically adjust air recirculation at a production site and plan FFU clusters for a cleanroom by integrating the FFU number, airflow speed, size, and other characteristics to ensure the quality of production and achieve energy savings targets.

*Keywords:* Minienvironment, clean room, fan filter clusters, cleanliness, energy savings, particle swarm optimization (PSO), metaheuristics algorithm.

### INTRODUCTION

#### Background

Clean rooms are built for products that have processes with cleanliness requirements to ensure that these products are not contaminated by dust, dust particles, microorganisms, chemical volatiles, or erosion. Clean rooms are frequently used for advanced processes. Minienvironments are closed, isolated spaces with different levels of cleanliness for different products and processes. Construction of minienvironments is required because of the rapid development of the production of high-tech and special products. Processes are categorized on the basis of their cleanliness requirements by using the International Organization for Standardization (ISO 14644-1, 2015). Manufacturers create air recirculation systems with fan filter unit (FFU) clusters in cleanrooms by using product and process cleanliness specifications to ensure that dust particle and volatile chemical levels do not exceed environmental cleanliness limits. In cleanroom spatial planning, key air recirculation systems can be constructed with FFU clusters (Xu, 2005) in an intelligent network to create minienvironment air systems corresponding to the requirements for each space.

#### Research Motivation

The main function of FFU clusters in cleanrooms is to perform clean air recirculation and ensure product and process cleanliness. In cleanroom design, a sufficient number of FFUs (Xu *et al.*, 2007) is required to filter clean air through wind speed adjustment to produce sufficient airflow volume in the dust-free space and control the cleanliness and particle concentrations. The cleanroom and minienvironment spaces must be provided by the air recirculation system with a sufficient air supply, air ventilation rate, wind speed, and power efficiency. Air recirculation systems are used to maintain cleanliness, and FFUs have substantial energy consumption.

High-tech and semiconductor companies have zero carbon emissions energy efficiency goals. Academic and industrial research is committed to ensuring high-quality products, high process yield rates, and reduced cleanroom energy consumption. However, the current high-tech industry has designed clean rooms and minienvironments by customizing FFU clusters for specific products and processes. If requirements change, readjusting facilities for energy savings is difficult.

The key equipment required to divide a clean room into minienvironments is an FFU cluster; these clusters require a significant proportion of the overall cleanroom energy consumption (Xu, 2008). To meet air cleanliness specifications, the number and the configuration of FFUs in a divided space often exceeds the cleanliness requirements to ensure a sufficient cleanliness level throughout the cleanroom (Xu, 2007). Therefore, the number of FFU clusters is increased to increase air recirculation and achieve a sufficient safety margin. Thus, FFUs in a cleanroom often operate at a higher cleanliness level than necessary to achieve these margins and to facilitate repurposing of a clean room for new processes with higher cleanliness requirements, resulting in energy efficiency.

The research motivation is as follows:

1. To use intelligent networking technology to adjust cleanroom FFUs and divide them into minienvironments with different cleanliness levels and
2. To resolve the problem of excessive energy consumption due to high cleanliness requirements by adjusting FFU cluster operation to increase energy efficiency.

## Research Purpose

This research focuses on the energy efficiency management of FFU clusters in divided and undivided minienvironment spaces in a cleanroom to verify the cleanliness of the cleanroom through experiments and analysis of quantitative data. The number of FFUs clusters is configured in each divided space to optimize the energy efficiency information used by a controlling intelligent network. Energy efficiency management problems can be due to changes in product or process cleanliness requirements; energy efficiency management targets could be met by using intelligent networking technology. Experimental verification was performed using the FFUs' energy power sensor module to obtain feedback and adjust the cluster to increase energy efficiency. The minienvironment can be adjusted to approximate the maximally efficient energy operation in a cleanroom by using this research model.

This research purpose is:

1. To develop a model for energy-efficient use of FFU clusters in a cleanroom.
2. To use a particle swarm optimization (PSO) model to increase the energy efficiency of FFUs and reduce the energy consumption of undivided cleanroom spaces.

## LITERATURE REVIEW

On the basis of the key parameter data of cleanroom environmental control and operation, the required cleanliness in divided into cleanroom spaces, the energy-efficient operation model and minienvironment FFU cluster energy efficiency were evaluated, and a metaheuristic algorithm with quantitative data analysis was used to model clean room minienvironments and determine how to increase energy efficiency (Xu, 2005).

Cleanroom minienvironments have fixed divided spaces and FFUs. A metaheuristic algorithm with cluster intelligence characteristics was used to determine the problem validity, and multiple feasible solutions were applied in an FFU cluster to identify an optimal solution. This paper discusses quantitative studies of particle cluster optimization algorithms, the basic characteristics of the clusters applicable to this research model, and the use of internet of things (IoT) technologies to collect the basic parameters of FFUs. Feedback, control, and adjustments were implemented in the model to facilitate clean room FFU adjustment.

### Control and Operation of Clean Room

The ISO-14644 2015 classes of air cleanliness by particle concentration were used to classify cleanroom cleanliness for control and operation.

### Minienvironment (FFU Cluster) Design and Operation

The cleanroom divides minienvironments (differential segmented cleanliness levels for production processes) by using FFU clusters to protect products sensitive to contaminants by creating isolated, enclosed spaces in existing production sites. Minienvironment operations primarily consist of implementing FFU clusters in air recirculation systems to provide a sufficient clean airflow rate and effectively control pollutant concentrations.

### Clean Room Classification

The ISO Classes of Air Cleanliness by Particle Concentration Guidelines include clean room and minienvironment air cleanliness classifications for specific industrial product implements or material requirement levels (ISO 14644-1, 2015).

### FFU Cluster Energy Efficiency in Minienvironments

FFUs recirculate air to provide sufficient clean airflow volume and maintain cleanliness. Their main functions are air recirculation, energy adjustment, and control of dust particles in clean rooms.

FFU clusters can be easily installed above the ceiling of a minienvironment, and effectively managing energy consumption results in considerable energy savings in a minienvironment compared with that in a clean room (Xu, 2007).

### Evaluating Minienvironmental Energy Efficiency Performance

The energy efficiency performance was evaluated in terms of airflow volume, airflow speed adjustment, and total power (watts) to determine the total energy consumption of the minienvironment. The less power is required per unit time, the higher the energy efficiency is. The energy efficiency performance indicator formula is power or airflow volume per unit of time [EPI =  $W/(m^3/min)$ ] (Xu, 2006).

### Key Energy Efficiency Parameters of FFUs with Intelligent Networking Technology

Air recirculation systems can be networked with wires or wirelessly. Sensors in the FFUs can monitor minienvironment energy consumption for a feedback control system; FFU speed can then be modified to approximate optimal operating parameters to provide sufficient clean air, control airflow speed, and optimize consumption efficiency by using repeated real-time data collection and feedback control. The FFU achieves approximately maximally efficient operation for a certain revolution per minute (RPM) requirement by using data such as airflow speed, energy consumption (W), airflow volume (Q), and efficiency

( $\eta$ ). FFU speed adjustment in the laboratory is used to produce energy efficiency data from the laboratory for implementation in minienvironment operations (Chen *et al.*, 2007).

Key parameter information, such as RPM, airflow volume ( $\text{m}^3/\text{min}$ ), airflow speed, power consumption ( $W$ ), and efficiency ( $\eta$ ) are associated with product and process requirements to adjust the value of the reference energy efficiency requirement, approximate effective energy efficiency, and quickly and flexibly adjust the FFUs' operation. Power consumption is defined as follows:

$$\text{Power } (W) = \text{Total Pressure Difference } (\Delta P) \times \text{Airflow Volume } (Q) / \text{Efficiency } (\eta). \quad (1)$$

Therefore, if the total value of the pressure difference ( $\Delta P$ ) can be maintained within a certain range of energy efficiency, the key parameter of an FFU is its airflow volume.

This study collected the key parameters for FFU energy efficiency. To reduce signal interference, mesh wireless IoT sensors were used to collect data, provide feedback, and control the FFUs. Moreover, an integrated wired (Wire RS485) energy efficiency control module was embedded in the FFUs to experimentally collect minienvironment field data and records of power efficiency to control the air recirculation system and adjust the FFU speed, airflow speed, and airflow volume. These data were collected for the target function value by approximating efficient energy consumption under the requirement of controlling the particle concentration (as the target value). The power density ( $W/\text{m}^2$ ) was used to adjust the airflow rate at a constant pressure difference (Pa). After the key energy efficiency parameters were collected, the operation of the air recirculation system of the controlled FFUs was adjusted in accordance with these parameters. The best solution identified by the algorithm was used to adjust the fan RPM, airflow speed in ( $\text{m/s}$ ), and airflow volume ( $Q_{\text{flow}}$ ,  $Q/\text{min}$ ) to achieve maximal energy efficiency.

### Metaheuristic Algorithm

The metaheuristic algorithm produces too many feasible solutions in a short period; thus, identifying the best solution quickly is difficult. An algorithm was developed to approximate the best solution at a reasonable cost; however, it does not guarantee the optimal solution. An iterative algorithm evolution program was used to increase the learning efficiency by guiding generations of solutions, exploring development solutions, using learning strategies with structural information, classifying metaheuristic algorithms (Zahra *et al.*, 2013), and solving for the approximate best solution of a cluster by using an iterative algorithm. In this study, a metaheuristic algorithm and PSO algorithm (Kennedy & Eberhart, 1995) were the most suitable for achieving a near-optimal solution for multiple clusters.

## RESEARCH METHOD

### PSO

The PSO algorithm was applied to FFU clusters because it is effective for finding the most feasible solutions in a cluster in situations where an optimal solution cannot be found immediately. The speed adjustment value is calculated through iterative memory and finally reaches the approximately optimal position when approaching a foraging direction path. The particle cluster optimization algorithm was adopted. The algorithm applies to all clusters and finds the most feasible solutions but requires substantial time. Iterative evolution is first solved and finally converges to an approximately optimal solution.

The PSO calculation stages are as follows (Kennedy & Eberhart, 1995):

1. Initial feasible solution.
2. Calculating the target value (fitness function).
3. Correction:

*Correction 1: Comparing best feasible solution position value  $pb_{(i,d)}$  of the flock of birds (particles).*

*Correction 2: Comparing best feasible solution position value  $gb_{(i,d)}$  of all the birds (particles).*

4. Calculating the speed adjustment value by using (1).

$$V_i(t+1) = wV_i(t) + c1r1[pb_{i,d} - X_i(t)] + c2r2[gb_{i,d} - X_i(t)] \quad (1)$$

5. Next-generation particle position: this generation's particle position + next generation's particle velocity vector adjustment from (2).

$$X_i(t+1) = X_i(t) + V_i(t+1) \quad (2)$$

6. They are iteratively calculating the corresponding value of the next-generation feasible solution to optimize the objective function.
7. Halting rules:

*Rule 1: Performing  $n$  generations ( $n$  is the confirmation generation number).*

Rule 2: Improvement below a fixed threshold (insufficiency affects the number).

### Model for FFU Cluster (Air Recirculation) Energy Efficiency Management

Energy efficiency parameters of FFU clusters were first identified, and the PSO algorithm was then applied to achieve optimal energy management.

The model parameters (Figure 1) and calculation steps are as follows:

Particle Swarm Optimization (PSO) implement on Fan Filter Unit Clusters, Parameters, Notations	
Parameters	
Notation	Description
PC	(Particles/m <sup>3</sup> ). Partilce Cleanliness
PN/s	(Particle Number/Second)Particle Number
AVR	Air Velocity Rate(Airflow Volume)
it	iteration
Sij	Product i, Process j, Air Speed in minienvironment (m/sec)
Nij	Product i, Process j, Fan Filter Units in minienvironment (m/sec)
Pi	Product i all process
PLbest,i	Particle (Feasible) Local Best search in own minienvironment
PGbest,i	Particle (Feasible) Global Best search in own minienvironment
C1, C2	Learning Factor
r1, r2	Random Variable
W	Inertia Weight
Lij	Low Bound
Uij	Upper Bound
TEC	Total Energy Consumption
EPI	Energy Performance Index
EPD	Electronic Power Density

Decision Variable): Nij, Fan Filter Unit Quantity in Minienvironment, Independent Variable:Sij Air Speed in Minienvironment . Fitness Function: Total Electronic Consumption,TEC

Source: This study.

Figure 1: Parameters of FFU clusters.

1. The feasible solution: FFU clusters in each divided space (multiple combinations of different FFU clusters in different processes).
2. Decision variable: the number of FFUs clusters in the minienvironment space.
3. Adjusted value: airflow speed.
4. Target value of fitness function: energy efficiency (total energy consumption [TEC]).
5. The number of FFU clusters in the next generation = the current number of FFU clusters + the next-generation adjustment value.

$$N_{ij}(it + 1) = N_{ij}(it) + S_{ij}(it + 1) \quad (2)$$

6. Next-generation airflow speed adjusted value = current airflow speed + the best value for the FFU clusters.

$$S_{ij}(it + 1) = S_{ij}(it) + C1r1 \times [PL_{best,i}(it) - N_{ij}(it)] + C2r2 \times [PG_{best,i}(it) - N_{ij}(it)] \quad (3)$$

7. Halting condition: TEC improves less than the influence value.

By using the decision variable of the minienvironment in cleanroom (FFU clusters), the airflow speed was adjusted to meet the target function minimizing TEC. A feasible solution for the minienvironment was generated and compared with the solution cluster to identify the optimal target value for energy consumption. The correction was performed to obtain the next generation of feasible solutions. After repeated calculation adjustments, a solution approximating the optimal minienvironment can be obtained. The target function for the approximately optimized energy-efficient solution was identified on the basis of the target cleanliness level.

The PSO algorithm was used to optimally operate an FFU air recirculation system. The key parameters for cleanliness and energy efficiency are as follows:

1. Particle cleanliness (PC): number of particles per cubic meter that are dust particles (particles per m<sup>3</sup>).
2. Particle number (PN/s): particles per second produced in the cleanroom.
3. Number of FFUs.
4. Cleanroom pressure value (Pa): the pressure in the cleanroom.

5. Air velocity rate (AVR): air produced per second in cubic meters (m<sup>3</sup>/s).
6. High-efficiency particulate air filter area (HEPA, A): square meters covered by HEPA (m<sup>2</sup>)
7. Airflow speed (S): airflow in meters per second (m/s).
8. TEC: total energy consumption of the cleanroom.
9. Energy consumption (EC): a minienvironment's energy consumption.

$$PC = (PN/s)/AVR \tag{4}$$

$$AVR = S \times A \tag{5}$$

$$PC = (PN/s)/AVR = (PN/s)/(S \times A) \tag{6}$$

$$S = (PN/s)/(PC \times A) \tag{7}$$

$$S_j = (PN_j/s)/(PC_j \times A \times n_j) \tag{8}$$

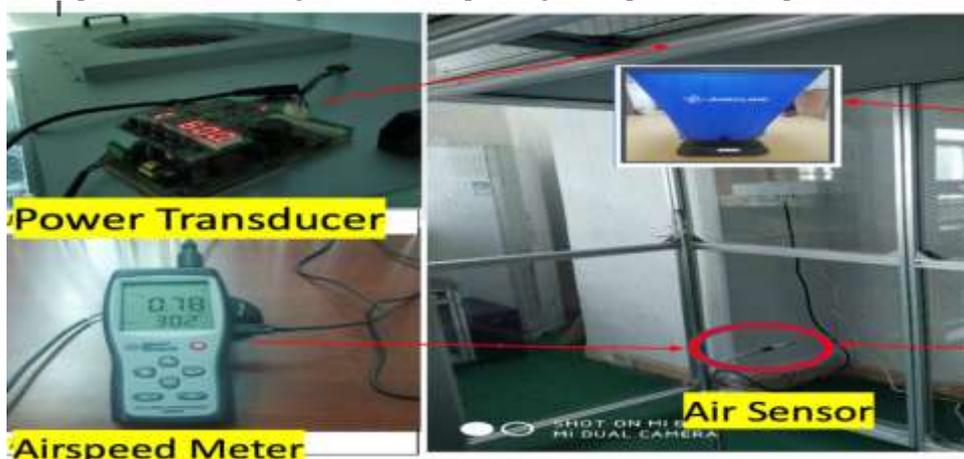
In process j, the airflow speed is S<sub>j</sub>, the particle number is PN<sub>j</sub>/s, the particle cleanliness is PC<sub>j</sub>, and the number of FFUs is n<sub>j</sub>.

### EXPERIMENTAL DESIGN AND RESULTS

#### Parameters of FFUs in Energy Efficiency Management Model

Key parameters of FFUs were collected using intelligent networking technology in the minienvironment (Figure 2 and Table 1).

1. AVR = airflow speed (S) × high-efficiency filter area (A), formula: AVR = S × A
2. Airflow speed: velocity measured using test equipment corresponding to the airflow speed of the FFUs in Figure 2.
3. EC: power consumption measured using sensors corresponding to the power consumption of the FFUs.



Source: This study.

Figure 2: Experimental design for FFU cluster parameters.

Table 1: Experimental results for FFU cluster parameters.

Fan Filter Units Experimental Parameters													
FFU RPM	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
Electric Power (W)	22.9	27.2	33.7	40.7	48.5	57.5	67.9	79.5	92.4	107.7	123.9	141.82	161.3
Airflow Speed (M/S)	0.26	0.29	0.34	0.36	0.42	0.45	0.45	0.57	0.59	0.68	0.78	0.78	0.79
Airflow Volume(m3/hour)	581.0	632.5	739.5	798.9	932.4	983.3	996.6	1249	1304	1501	1581	1710.3	1735.6
Energy Performance Index (m3 air /Watt per Hour)	25.4	23.25	21.94	19.63	19.16	17.10	14.67	15.71	14.1	13.93	12.76	12.059	10.76
Airflow Rate through the Cleanroom, minienvironment (Watt /m3 air per Hour)	0.04	0.043	0.046	0.051	0.052	0.058	0.068	0.064	0.07	0.072	0.078	0.083	0.093

Source: This study.

MODEL VALIDATION

Experimental Situation

Experimental site and facility conditions

Production of a mobile phone camera module in a cleanroom.

1. Manufacturing process:
  - (1) Cell phone lens sensor chip packaging.
  - (2) Optical focus correction.
  - (3) Lens optical module assembly.
2. Minienvironment classification of cleanliness (different working spaces, different cleanliness classes, three minienvironments).
  - (1) Cleanliness level 5 for the first minienvironment.
  - (2) Cleanliness level 5 for the second minienvironment.
  - (3) Cleanliness level 6 for the third minienvironment.
3. Using FFU clusters with the energy efficiency management model to reduce power consumption.
4. Cleanroom space: 18 m (width) × 30 m (length) × 2.5 m (height), area (square meters): 540 m<sup>2</sup>, space (cubic meters): 1,350 m<sup>3</sup>.
5. FFUs are equally distributed in the cleanroom.
6. All FFUs must be running (otherwise, pollutants will enter).
7. The airflow speed is the same as that in the minienvironment.
8. Number of FFUs: 100 units, three different processes, 100 units/540 m<sup>2</sup>, 1 unit = 5.4 m<sup>2</sup>
9. FFU specifications: 0.57 m (width) × 1.1 m (length) × 0.25 m (height).
10. HEPA: nondamaged, unclogged.
11. The pressure difference (Pa): maintained in the range of 10–15 Pa.
12. Objective function: TEC.

Energy efficiency management model of PSO algorithm

$$n_{ij}(t+1) = n_{ij}(t) + s_{ij}(t+1) \tag{9}$$

$$s_{ij}(t+1) = Ws_{ij}(t) + C1r1(PL_{best} - n_{ij}(t)) + C2r2(PG_{best} - n_{ij}(t)) \tag{10}$$

1.  $n_{ij}$  = number of FFUs (calculated and adjusted by the algorithm).
2.  $s_{ij}$  = airflow speed (after calculating the airflow volume to check the parameters of FFUs in the energy efficiency management model).
3.  $W$ : inertial weight, constant value (0.8 – 1.2).
4.  $C1, C2$ : learning factor  $C1 = C2 \in [1, 2.5]$ , the usual value is 2.
5.  $r1$  and  $r2$  are random parameters in (0,1).
6.  $L_{ij}$  = minimum number of fans (given by process).
7.  $U_{ij}$  = maximum number of fans:

$$U_{ij} = N - \left\lceil \sum_{k=1}^{j-1} L_{ik} \right\rceil \left\lfloor \sum_{k=j+1}^{NP_i} L_{ik} \right\rfloor \tag{11}$$

(Total number of fans: the sum of the least number of fans in the remaining space).

Results for calculated feasible solutions after the first generation of PSO (Table 2).

Table 2: Calculated feasible solutions for the first generation of PSO.

Cleanliness Class 5-6, First Generation, t=1, Particle Swarm Optimization Algorithm in Minienvironments														
10 Feasible, Pressure Differences 10-15Pa, FFU: 100 Sets, 3 Minienvironments : 18M(W)*30M(L)*2.5M(H) Square Meters 540m2, Cubic Space 1,350m3,														
Product : Process (FFU Qty/nj)   Low Bound:Lnj, Upper Bound:Unj   (1, 100) Fitness Function: Total Electronic Consumption(TEC); Each FFU per 5.4m2=1 Set														
All FFUs are running in Minienvironments, Speed all is same														
FFU Qty	Feasible	Air Flow Volume = m3=FFUs*Air Change Rate			Check Experimental Parameters						Power (Watt)	Energy Efficiency EPI (W/m3/min)	Electronic Power Density (W/m2)	
		n1, Air Change Rate 70 Times (Cleanliness 5) L1=18 U1=48	n2, Air Change Rate 70 Times (Cleanliness 5) L2=15 U2=42	n3, Air Change Rate 70 Times (Cleanliness 6) L3=30 U3=42	s1 Air Speed(m/ sec)	s2 Air Speed(m/ sec)	s3 Air Speed(m/ sec)	Air Flow Volume Q1=m3	Air Flow Volume Q2=m3	Air Flow Volume Q3=m3				
100	1	25	25	50	0.4456	0.4456	0.3351	24583.752	24583.752	36974.934	4359.5	0.053	8.44	
100	2	24	28	48	0.4456	0.4456	0.3351	23600.402	27533.802	35495.937	4807.08	0.053	8.53	
100	3	23	31	40	0.4456	0.4456	0.3351	22617.052	30483.852	34016.939	4654.66	0.053	8.62	
100	4	22	34	44	0.4456	0.4456	0.3351	21633.702	33433.903	32537.942	4702.24	0.054	8.71	
100	5	21	37	42	0.4456	0.4456	0.3351	20650.352	36383.953	31058.945	4749.82	0.054	8.80	
100	6	24	30	46	0.4456	0.4456	0.3351	23600.402	29500.502	34016.939	4654.66	0.053	8.62	
100	7	23	24	53	0.4456	0.4456	0.3351	22617.052	23600.402	39193.43	4488.13	0.053	8.31	
100	8	22	29	55	0.4456	0.4456	0.3351	21633.702	22817.052	40672.427	4440.55	0.052	8.22	
100	9	21	21	58	0.4456	0.4456	0.3351	20650.352	20650.352	42890.923	4369.18	0.052	8.09	
100	10	20	20	60	0.4456	0.4456	0.3351	19667.002	19667.002	44369.921	4321.6	0.052	8.00	

Source: This study.

**Benchmarking Comparison**

A power consumption evaluation was performed by comparing spaces with three types of cleanrooms.

1. Cleanroom undivided spaces (Table 3).
2. Cleanroom divided spaces, nonadjustable mini environments (Table 4).
3. Cleanroom divided spaces (this study), adjustable mini environments (Table 5).

Table 3: Power consumption in undivided cleanroom spaces.

1. Clean room undivided spaces.									
Pressure Differences 10-15Pa, FFU 100 Sets : 18M(W)*30M(L)*2.5M(H) Squire Meter 540m2, Cubic Meter 1,350m3, FFU=ni <sub>j</sub> , Air Speed =Sij									
		Air Flow Volumn = (m3/Each)*FFUs*Air Change Rate			Check Experimental Parameters				
Fan Filter Units	Feasible	100 FFUs, Air Change Rate 70 Times (Cleanliness Class 5).			sij(Air Speed) m/sec	Air Flow Volumn Q*m3	Power (Watt)	Energy Efficiency EPI (W/m3/min)	Electronic Power Density (W/m2)
100	1	100			0.4456	98336	5749	0.058	10.646

Source: This study.

Table 4: Power consumption in divided cleanroom spaces, nonadjustable minienvironments.

2. Clean room divided spaces, nonadjustable mini environments .													
Pressure Differences 10-15Pa, FFU 100 Sets : 18M(W)*30M(L)*2.5M(H) Squire Meter 540m2, Cubic Meter 1,350m3, FFU=ni <sub>j</sub> , Air Speed=sij													
		Air Flow Volumn = m3*FFUs*Air Change Rate			Check Experimental Parameters								
FFU Qty	Feasible	ni1, Air Change Rate 70 Times (Cleanliness 5). Lij=18 Uij=45	ni2, Air Change Rate 70 Times (Cleanliness 5). Lij=15 Uij=42	ni3, Air Change Rate 70 Times (Cleanliness 6). Lij=40 Uij=67	si1 Air Speed(m/ sec)	si2 Air Speed(m/ sec)	si3 Air Speed(m/ sec)	Air Flow Volumn Q1*m3	Air Flow Volumn Q2*m3	Air Flow Volumn Q1*m3	Power (Watt)	Energy Efficiency EPI (W/m3/min)	Electronic Power Density (W/m2)
100	5	21	37	42	0.4456	0.4456	0.3351	12145.849	21399.828	18267.836	4749.82	0.092	0.817

Source: This study.

Table 5: Power consumption in divided cleanroom spaces, adjustable minienvironments.

3. Clean room divided spaces , adjustable mini environments													
Pressure Differences 10-15Pa, FFU 100 Sets : 18M(W)*30M(L)*2.5M(H) Squire Meter 540m2, Cubic Meter 1,350m3, FFU=ni <sub>j</sub> , Air Speed Sij													
		Air Flow Volumn = m3*FFUs*Air Change Rate			Check Experimental Parameters								
FFU Qty	Feasible	ni1, Air Change Rate 70 Times (Cleanliness 5). Lij=18 Uij=45	ni2, Air Change Rate 70 Times (Cleanliness 5). Lij=15 Uij=42	ni3, Air Change Rate 50 Times (Cleanliness 6). Lij=40 Uij=67	si1 Air Speed(m/ sec)	si2 Air Speed(m/ sec)	si3 Air Speed(m/ sec)	Air Flow Volumn Q1*m3	Air Flow Volumn Q2*m3	Air Flow Volumn Q1*m3	Power (Watt)	Energy Efficiency EPI (W/m3/min)	Electronic Power Density (W/m2)
100	10	18	15	67	0.4456	0.4456	0.3351	17700.301	14750.251	49546.412	4155.07	0.051	7.69

Source: This study.

**CONCLUSION**

The energy management model was verified through experiments, and the air recirculation system can be introduced to adjust the airflow volume and airflow speed of the FFU clusters. The PSO algorithm with the metaheuristic algorithm was used. The quantitative research data analysis revealed that energy efficiency could be increased. Cleanroom energy efficiency consultants and production plan designers could effectively split a cleanroom into minienvironments to reduce the TEC of the FFU clusters to increase energy efficiency, produce high-quality products, and flexibly adjust to changing requirements.

The paper achieves the following:

1. We are applying PSO to develop a model for energy-efficient FFU clusters in a cleanroom.
2. We are demonstrating the model’s ability to increase the energy efficiency of FFU clusters in a clean room on the basis of the experimental results.

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## A Netnography of the Social Media Presence of Brand Netflix, India

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### ABSTRACT

Social media marketing is growing at a rapid pace. Marketers need to keep up with technology-savvy consumers and help the brands in reaching greater heights with the help of social media practices. This manuscript presents how an Over-the-Top platform like Netflix India uses social media as a digital tool for enhancing consumer engagement and building strong consumer-brand relationships using netnography as a tool. This manuscript further attempts to classify the content generated by Netflix India on its social media platforms- Instagram, Facebook, Twitter into diverse content typologies, identify the most significant content typology, and understand how the number of likes, comments, shares, retweets (in case of Twitter) relating to most significant content typology impacts the enhancement of consumer engagement amongst Netflix audience. Thereafter, the research study classifies the content generated by Netflix into three categories, namely- informational content, promotional content, and relational content. The study is further able to empirically illustrate how a greater number of likes, shares, comments, and retweets on relational content has a significant impact on consumer engagement of the brand Netflix.

*Keywords:* OTT platforms, social media marketing, netnography, consumer engagement, Netflix.

### INTRODUCTION

OTT Platforms are media service platforms where media services are offered to viewers directly with the help of the internet. In India, people spend at least 40 minutes per day on these platforms. The online video market in India is one of the largest growing markets in India. It is estimated that by the year 2023, India will have close to 500 million viewers who would make it the second-biggest market in the world after China, with OTT platforms contributing a major portion of its growth. The Covid-19 situation led India to get locked inside the houses leading the economy to slow down immensely. However, this strict lockdown has boosted media consumption. The OTT platforms got immense love and positive response and became one of the major sources of entertainment for viewers. The very first OTT platform in India was by Reliance, which did not gain much popularity. Although it is appropriate to say that the media and entertainment industry suffered a lot due to the whole pandemic scenario and lockdown, but OTT platforms got quite the benefit because of it. It made watching content such as movies, web series, daily soaps, etc., very convenient and readily available. Anyone with a mobile phone (or any electronic device) with internet connectivity can watch content from anywhere in the world. OTT platforms seem to be a new alternative to watching movies in cinema halls, and many of the filmmakers are considering this as an option to make their content readily available to viewers in a hassle-free manner. Only one membership is required, and a whole family can enjoy watching several movies and other content of their own choice, that too being in the comfort zone of their own homes and without burning a hole in their pockets. Over the past few decades, marketing has had to keep up with the growing pace of technology and maintain a perfect relationship with it. In contemporary times, digital and social media marketing are being used by marketers to enhance brand visibility, solicit consumer engagement, and build a strong consumer brand connection.

Internet users in India are growing at a fast rate. (Moochhala, 2018) Even though the internet helps in a lot of aspects but one of the main reasons for using the internet among people is for entertainment purposes. Slowly, people are shifting from traditional media platforms such as TV and cinema to OTT platforms for various reasons, some of them being OTT Platforms is a digital entertainment space that needs no censor board, users have a lot of options to choose from, there are no or minimum advertisements, there is a comfort and convenience in watching the content at any time and any place. The popularity of digital platforms has grown, given the conditions that there is internet availability, connection speed, smartphones, or gadgets available. The Digital India campaign also boosts the adaptability of the digital platform among consumers. There are various OTT players in the market, among which Amazon Prime Video is the most popular OTT platform, after which comes Netflix. The reason behind this popularity is found out to be localized regional content that is loved by the audience. Over the last few years, this sector has shown significant growth. As per the research and find, it can be said that OTT platforms have made their place in the industry, giving a strong competition to traditional cable television and cinema to the extent that it can overgrow the traditional media platforms. It can be evidently seen that the entertainment industry is in the process of a full transformation to digital entertainment. OTT Video platforms which were once considered a luxury, are now merely a commodity. People get to watch relatable content and experience visual quality (Sundaravel & Elangovan, 2020) with the help of a good internet connection. In India, there are approximately 40 OTT platforms, and the rate at which this industry is growing, the numbers are expected to reach 100 by 2023. Nevertheless, in India, there is a large population in rural areas without internet access. Thus, there is a lot of potentials to grow and reach more people. OTT platforms are at a stage where growth is at a rapid pace, and it is a golden opportunity for content creators because entry barriers are usually negligible. Even though the popularity of OTT platforms is

increasing, but there is still a large segment that is hooked up to televisions and traditional video platforms. To completely replace the traditional OTT platforms, one must undergo a lot of advancement and get the right kind of business model.

Netflix is an online streaming platform and is one of the leading entertainment providers in the world. It has its headquarters in Los Gatos, California, United States. Netflix entered the Indian market in 2016 when it captured only a niche segment of English-speaking and urban audiences. Over the last few years, Netflix has upgraded its content strategy and has been able to cater to different segments, classes, thinking, regions, choices, and tastes of people. Netflix has become more accessible and is not only being available on very high-end devices and smart TVs but also on smartphones. Main USP is its original content with which the audience can relate to. Netflix has been able to use digital marketing and social networking sites to market its content, be in touch with the audience, and maintain its relationship with viewers. This manuscript analyses the social media presence of OTT brand Netflix using the research methodology of netnography and identifies the different types of content typologies posted by the company to build a strong consumer-brand relationship and enhancement of consumer engagement.

## REVIEW OF LITERATURE

### Digital Marketing (DM)

Digital marketing cannot be considered as a mere another channel of marketing (Durai & King, 2015). Rather it is a new approach to marketing that helps in reaching and understanding the consumers in a much better way. With an increase in the adoption of Digital Marketing practices by almost all organizations, most marketers focus on social media marketing which has led the social networking sites to change their aim from bridging the gap between people to being a valuable marketing tool. But exploring only one tool is not efficient. Therefore, while making marketing strategies, it is important to include a combination of all digital marketing tools to compete better in the market, satisfy and retain consumers and earn a good revenue out of it. To grow in such a dynamic environment, companies should constantly keep up with the changes and inculcate those changes in their marketing activities. Also, focusing on marketing factors, service factors, functionality factors, and consumer expectation factors will help the businesses to keep in touch and be aware of consumer needs and their expectations. Digital marketing is effective not only for the marketers but also for the (Yasmin, Tasneem, & Fatema, 2015) consumers and marketers. Because DM consumers are free from constraints about the information available to them, they can easily obtain information at any time and any place through digital media.

There is a positive relationship between Digital marketing practices and the sales of firms. Digital marketing is still growing and has become an important part of the business strategies of many companies. The marketing mix has evolved and changed over the years. In such a competitive environment (Jackson & Ahuja, 2015), where each business must compete with others in the market to gain the consumers' attention, digital marketing has played an important role. The updated version of integrated market communication can be called DMC 2.0 (Digital Marketing Communication 2.0). This new version typically focuses on engaging with the consumers and trying and make them develop loyalty to the brand. It takes the help of analytics to gain knowledge about the responses and make decisions accordingly. It makes use of Social Media Marketing and Viral Marketing to reach consumers and communicate with them. However, the main goal of both traditional IMC and DMC 2.0 is to convince people to buy products/services, create an image in their eyes and develop loyalty in their hearts. With the emergence of digital media (S & Rungta, 2016), the term digital marketing has also grown, and so has its impact. People use the words internet marketing, web marketing, and digital marketing interchangeably, but these are not the same. Internet marketing is only a part of Digital marketing. All the channels that use the internet as a platform to promote their product/service come under internet marketing. Digital marketing comprises both channels, online and offline.

With the rapid growth of technology, digital marketing practices are also used in offline marketing. It is crucial to understand this difference because it helps in selecting the relevant marketing tool and helps the marketers to plan the marketing strategy accordingly. Digital Marketing typically includes marketing various products/ services (Sathya, 2017) through digital technologies, usually by the internet. It also includes smartphones, digital websites, and any other digital media form. DM is at a growing stage, and several campaigns are being conducted. Companies use digital platforms to promote their products/ services, and it is incorporated into their marketing plans to increase their reach. It allows consumers to make their purchase decision at any time of the day without any time constraint, making it easy and convenient for them. People are getting aware of digital marketing practices rapidly, and it has a very bright future and present in the market. Even small entrepreneurs are inculcating DM practices into their marketing plan (Stroud, 2005). It has a lot of potential given that consumers' needs are treated as a top priority.

In India, the digital economy is rising at a rapid pace (Rathore, Pant, & Sharma, 2017). After getting a push by demonetization of Indian currency, digital payment schemes launched by the Indian Government and telecom sector also played their part. Therefore, it is crucial that any product/service has internet or digital presence and visibility more than a traditional market presence. Most organizations are spending their money on digital marketing practices rather than traditional strategies. With the rise in the digital marketing industry, marketers are learning digital skills, and job roles are also increasing. Consumers want the best deal for them, and DM makes it easier for them to research the same. It is cost-effective and has a good impact on business. (Garcia, Lizcano, Ramos, & Matos, 2019) Digital marketing and the internet have now become key components of marketing strategies in almost all organizations. There are various ways by which new users and consumers can be generated and retained with their help. The new market is said to be market 2.0, and to compete and maintain one's place in this market, organizations are amalgamating their advertising strategies with ICT (Information and Communication Technologies). B2C businesses in the

future will have to use AI and internet of things technology to assure customer loyalty.

The digital sector is evolving at a rapid pace, and thus it is important to keep up with the pace and upgrade the marketing strategy accordingly. It is still at a growing stage, which has both long-term and short-term developments and achievements that it'll face. Mobile phones and AI play an important role in DM, and it will further increase as it grows in the long run. India is a country with a large population and a lot of opportunities coming up for the people. One such opportunity is Digital Marketing, and this field is growing how wildfire spreads in a forest. This is also possible because of the 'Digital India' initiative that the Government of India launched to convert India into a digitally empowered and knowledgeable society. It does not constrain itself within the borders of India; rather, it helps to increase the reach and connect to people and be global. With the help of social media platforms and its highly active consumers, the engagement rate is growing fast. But to be trending or viral on social media, one needs to be creative and adapt to changes. To stay in the market, compete and generate leads, companies need to be creative and adapt the innovations in the marketing field.

### Social Media Marketing (SMM)

Social media marketing is extensively used by brands to converse with their consumer base. Owing to the high level of interactivity of this medium (Assaad & Gómez, 2011), the consumers have greater control and power over the information that they want to consume and the brands they want to interact with. This can help brands in formulating profitable relationships. Social media marketing enables brands to build consumer brand loyalty (Erdogmus & Çiçek, 2012). In a rapidly growing business environment, it is easy to grab consumer attention for a short duration. However, marketers need to focus on building a long-term relationship with their consumers and regularly stimulating repurchase intent.

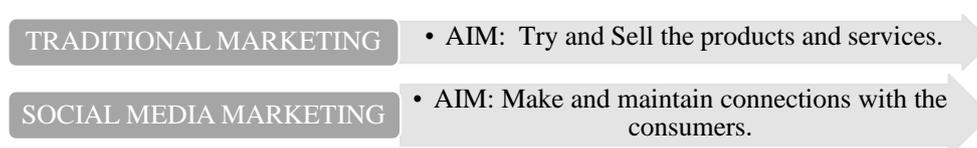


Figure 1: Difference between aims of traditional marketing and social media marketing.

To be resourceful and useful on social media platforms, brands are now hiring social media experts who understand the consumers and provide relevant and updated content for their benefit. However, it is a new platform but is growing at a rapid pace which helps the brands to connect with consumers and create a positive image in their eyes. The advantageous campaigns on social media are the most remarkable factor of brand loyalty. Companies should focus more on creating content that is entertaining and fun along with relevance and maintaining their presence on all social media platforms. This new area of marketing shows a lot of potential regarding the brand loyalty of consumers. When the consumers are loyal to a particular brand, they tend to promote that brand on their own. Social Media Platform is easily accessible to people (Bajpai, Pandey, & Shriwas, 2012) with the help of the internet. It not only helps to promote products and services on an online platform but also works as a word of mouth because people can comment and read other people's comments which helps in increased engagement and traffic for a brand. This kind of personal interaction helps to build trust among the audience and potential consumers. The consumers who participate actively also become part of a marketing team because anyone can read their comments and reviews. Social media platforms have their own ecosystem with the help of which brands and companies can increase presence and build community. However, it is only the first part of SMM. Converting this community into consumers is the true power. Rewarding consumers with a token of appreciation, engaging with them on a regular basis, being consistent and approachable are some strategies that should be added to the marketing plan to stimulate revenue and reach.

Social media is the new marketing tool (SI,2016) that is going to benefit businesses, just like e-mail and websites. It not only helps in spreading the information but also increases bi-variate engagement. The platform, which was once used to connect with family and friends and network with otherpeople, has now become a great platform for marketing. It is an excellent way to strategize and reach the audience, establish thereputation of the company and its impact. Even though social media has a vast reach, the companies only cater to a particular targeted segment in a very customized way. The marketer should first analyze how SMM benefits the company and try to figure out a perfect way. Even though social media is a fast platform, but nothing can happen overnight. Using SMM along with othermarketing tools will give excellent results to the companies. Social networking sites have shown growth in the last few years magnificently. It helps the brands to connect to their existing consumers and target audience (Sharma, Alavi, & Ahuja, 2019) ina convenient and comparatively affordable way. The study shows that there is a positive relationship between brand loyalty & trust among consumers and the number of posts, comments, shares, and reactions across the three social networking sites, namelyFacebook, Instagram, and Twitter.

There is a total of five levels of online engagement that are like, reactions, comment, sharing, and co-creation.

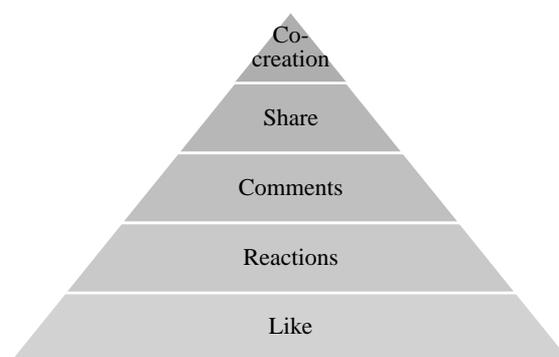


Figure 2: Five levels of online engagement.

A consumer engages with a brand only when he/she feels comfortable and connected to the content and brand itself. The concept of “online engagement” is important for a brand. Social networking sites make the audience go from the awareness stage to the engaging stage. As people are now active on the internet much more than ever, companies should use social media analytics to understand consumer insights and competitors’ strategies to upgrade their plans and work accordingly.

### RESEARCH OBJECTIVES

This study focuses on the following research objectives:

- 1.1 To study the social media presence of the brand Netflix.
- 1.2 To identify the diverse types of content posted by the brand on its social media pages.
- 1.3 To understand the marketing objectives achieved by the different content typologies.
- 1.4 To conduct a comparative study on which type of content generates the most consumer engagement.

### RESEARCH METHODOLOGY

This study makes use of the research method of netnography to study the social media page of Netflix, i.e., Instagram, Facebook, Twitter, and identify the different types of content typologies posted by the company. The study further uses Regression analysis to analyze which content typology has the maximum consumer engagement. Secondary data has been used to

#### Netnography

Netnography is a qualitative research methodology that uses techniques of ethnography but in an online medium. (Kozinets, 2002) Ethnography is a study of consumer behavior, choices, and patterns. Likewise, netnography is the study of consumer behavior, community patterns, and cultures but in a computer-based technology and online mode. Netnography collects data by using publicly available information to observe, identify and understand the decisions, viewpoints, and preferences of online user groups.

It is a simpler, faster, and cheaper technique in comparison with ethnography (Ahuja & Alavi, 2018) as the data is to be collected online, and the data is available all in one place. The main aim of netnography is to prospect what the brand is posting and how the users are responding to it, furthermore how brands are then responding to users’ reactions. It is important for brands to frequently monitor their content online so that they can make sure that the content is relatable to the targeted audience. (Chandpuri & Ahuja, 2020). It is fundamental to acknowledge the content typology that users engage with and to observe and understand users’ feelings and sentiments. This methodology allows an in-depth exploration of consumer behavior, consumer relationship, and consumer engagement with a particular brand on a particular online medium or community.

#### Regression

Regression analysis is a versatile and significant statistical tool that helps to analyze the degree of a possible relationship between a dependent variable and one or more independent variables. It helps in understanding which factors affect the most, which can be ignored, and how these factors are related to each other. In this manuscript, multiple regression analysis is conducted to study the impact of likes, comments, shares, and a total number of posts on enhancing consumer engagement on Facebook, Instagram, and Twitter Netflix. Consumer engagement is taken as a dependent variable, and the number of comments, number of posts, number of likes, and reactions are taken as independent variables.

#### *Regression model of consumer engagement generated on Facebook*

In this model, regression analysis of content posted by Netflix on Facebook is computed, which contributes to consumer engagement. We have assumed that there is a linear relationship between the number of posts made by Netflix, the number of likes and reactions given by consumers, the number of comments posted by consumers, and shares done by consumers. The engagement generated is measured by the number of shares. Here we take engagement generated as a dependent variable which can be measured by the number of shares done by the consumers. (Yuki, 2015) The number of posts, number of likes and reactions, and number of comments on these posts are considered independent variables.

***Regression model of consumer engagement generated on Instagram***

A regression model is constructed for determining the consumer engagement generated by Netflix on Instagram by the content posted on their Instagram account. Here we have taken the number of posts and number of likes as independent variables and consumer engagement generated by means of comments as the dependent variable, 'comment' being the highest level of engagement on Instagram by the consumer after content is posted by the brand.

***Regression model of consumer engagement generated on Twitter***

A separate regression model is developed to analyze the level of consumer engagement generated by content posted on Twitter by Netflix. Here also, we have assumed that there is a linear relationship between the number of posts done by Netflix, the number of favorites given by the consumers, and the number of replies by consumer consumers. Consumer engagement is measured by the number of retweets done by the consumers. 'Retweet' is nothing but re-sharing of the content consumers like or can relate to by consumers, which was once posted by the brand. A retweet is the maximum level of engagement a consumer can do on the content posted by a brand on Twitter.

**HYPOTHESIS**

For the research framework, the following hypothesis has been constructed:

- H1: There is a significant impact of the informational content of Netflix on consumer engagement on Facebook.
- H2: There is a significant impact of the informational content of Netflix on consumer engagement on Instagram.
- H3: There is a significant impact of the informational content of Netflix on consumer engagement on Twitter.
- H4: There is a significant impact of the Promotional content of Netflix on consumer engagement on Facebook.
- H5: There is a significant impact of the Promotional content of Netflix on consumer engagement on Instagram.
- H6: There is a significant impact of the Promotional content of Netflix on consumer engagement on Twitter.
- H7: There is a significant impact of the Relational content of Netflix on consumer engagement on Facebook.
- H8: There is a significant impact of the Relational content of Netflix on consumer engagement on Instagram.
- H9: There is a significant impact of the Relational content of Netflix on consumer engagement on Twitter.

**RESULTS, ANALYSIS, AND FINDINGS****Content typologies**

A netnographic analysis of the social media pages of Netflix was conducted, and 28 types of content were extracted. These were categorized into three content typologies, namely Informational content, Promotional content, and Relational Content.

*Informational content* is the type of content posted by an organization online through which information can be provided to the audience. (Dolan, Conduit, Fahy, & Goodman, 2016). Consumers use the internet to entertain themselves but also to gain some information regarding various topics, and this can be said to be one of the main reasons that consumers make use of the internet.

*Promotional content* is the content that shares information about the upcoming projects, new releases, collaborations with other major personalities, teasers for new releases. (Ahuja & Alavi, 2018) It also includes content or posts influencing the users to welcome and accept new projects in a good way.

*Relational content*: A human is a social being. People tend to use the internet and social media for social interaction and for a sense of inclusiveness. Users try to find a comfortable place to share their feelings, views, and information and to update their family and friends about their life. Social media facilitate user engagement and interaction with the brand and with fellow users. Relational content is the content posted by a brand which the users find relatable and of great significance to them. The main aim of this type of content is to make users interact with them and to establish a good relationship with the users.

***Regression model of Informational Content***

Regression analysis for Facebook was conducted for a total of 288 posts which was hosted by Netflix over a period of 12 months. The overall fit statistics and multiple regression model are presented in Appendix A. we found out that the adjusted  $R^2$  of our model is 0.726 and  $R^2$  is 0.733. With this, we understand that the regression model explains 73% (approximately) of the variance in the data. Further, the results of the F-test indicate there is a linear relationship among the variables. Beta values indicate the standardized coefficient values of the independent variables. The beta values for each of the variables for Facebook, that is, reactions and comments, are significant and positive, which reflects that they all have a direct impact on consumer engagement. The variable "comments" have the highest influence (beta= 0.585) on the enhancement of consumer engagement. Thus, we can

accept H1 based on the above discussion.

Table 1: Classification of content typology.

Informational content	Promotional content	Relational content
<ul style="list-style-type: none"> <li>• Posting pictures of the cast of the show informing the date of release of the show.</li> <li>• Informing about the new hashtags to follow for upcoming challenges related to new content</li> <li>• Combining the nation news along with the relatable content available</li> <li>• Converting promoting content into the news as “newsflix.”</li> </ul>	<ul style="list-style-type: none"> <li>• New series/ movie</li> <li>• Collaborating with influencers to promote content</li> <li>• New filters for every new show/series/ movie</li> <li>• Hashtags related to new content</li> <li>• Teasers for new shows</li> <li>• Sharing memes related to new content</li> <li>• Posting little spoilers for new shows for better consumer engagement.</li> </ul>	<ul style="list-style-type: none"> <li>• Celebrating festivals</li> <li>• Contests</li> <li>• Parents day specials</li> <li>• Celebrating friendship day with “friends” from a particular show.</li> <li>• Challenges with friends performed by celebrities from upcoming shows/series/ movies</li> <li>• Reasons to watch new content</li> <li>• Down the memory lane (promoting some old content or a character of some old content)</li> <li>• Comparing Hollywood content with regional content (finding similarities and differences)</li> <li>• Story highlights for popular shows/movie/series</li> <li>• Keeping up with the trends and creating promotional content around them.</li> <li>• Story highlights for news from the entertainment industry</li> <li>• Wishing collaborating celebrities on their birthdays and congratulating them for success</li> <li>• Celebrating success and completion of years of popular and original shows/series/movies</li> <li>• Social media campaigns <ul style="list-style-type: none"> <li>-April fools day (just at the start of lockdown, Netflix reminded us to spend some quality time with ourselves, to clear our minds, and to watch some of their content.) (health awareness)</li> <li>-promoting original content (making social media pages for the characters of the show and posting in real-time on their feeds)</li> <li>-Social causes for regional as well as global (black lives matter, body positivity)</li> </ul> </li> <li>• Choosing favorites from a particular genre of content</li> <li>• Giving witty and interesting replies to audiences’ comments.</li> <li>• promoting safety measures with the help of characters of a content</li> </ul>

For Instagram, regression analysis was conducted for a total of 420 posts which was hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  of our model are 0.179 and 0.191, which indicates that the regression model explains approximately only 18% of the variance in the data, which is comparatively low. The F test shows that there is a linear relationship among the variables. The beta coefficient for the variable likes is positive and significant ( $\beta = 0.437$ ); thus, it can be said that likes have a direct impact on the enhancement of consumer engagement. Therefore, we can accept H2 according to the results.

Table 2: MLR model for informational content.

Items	Facebook	Instagram	Twitter
Total number of Posts	288	420	450
Total number of Likes/Reactions/Favorites	7,09,304	6,22,07,928	14,63,490
Total number of Comments	54,800	1,69,104	31,644
Total number of Shares/Re-tweets	1,16,844	-	2,67,498
Adjusted R Square	0.726	0.179	0.755
R Square	0.733	0.191	0.762

For Twitter, regression analysis was conducted for 450 total posts hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  of our model are 0.755 and 0.762, respectively. This indicates that the regression model explains 75% (approx.) of the variance in the data. Here also, F-test shows that there is a linear relationship among the variables. The beta values for both the independent variables, i.e., favorites and comments, are positive and significant. Interestingly, the variable “favorites” has the highest impact between the two independent variables with the beta value of 0.759. Thus, we can accept H3, which indicates that favorites and comments have a direct impact on the enhancement of consumer engagement.

#### **Regression model of Promotional Content**

Regression analysis of Facebook was conducted for 304 posts that were hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  for our model are 0.893 and 0.896, which means that the regression model explains approximately 89% of the variance in the data. The F test indicates that there is a linear relationship among the variables. The beta value for both the variables is positive and significant, which shows the direct impact of reactions and comments on the enhancement of consumer engagement. Therefore, we can accept H4 based on the above discussion.

For Instagram, regression analysis was conducted for 714 posts that were hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  of our model are 0.329 and 0.334, respectively, which indicates that the regression model explains approximately only 33% of the variance in the data. The F test reflects that there is a linear relationship between the variables. The beta value of the independent variable (likes) shows a value of 0.578, which is both positive and significant. Thus, we can accept the hypothesis (H5) and conclude that according to the results, the variable likes have a significant impact on the enhancement of consumer engagement.

Table 3: MLR model for promotional content.

Items	Facebook	Instagram	Twitter
Total number of Posts	304	714	540
Total number of Likes/Reactions/Favorites	18,32,584	8,33,11,110	12,02,178
Total number of Comments	57,440	2,08,542	31,902
Total number of Shares/Re-tweets	1,50,768	-	2,17,236
Adjusted R Square	0.893	0.329	0.810
R Square	0.896	0.334	0.814

For Twitter, regression analysis was conducted for 540 posts that were hosted by Netflix over the period of 12 months. The adjusted  $R^2$  and  $R^2$  for our model are 0.810 and 0.814, respectively, which means that the regression model explains approximately 81% of the variance in the data. The F test shows that there is a linear relationship among the variables. The beta value for the independent variables is significant and positive, and thus it can be said that they have a direct impact on the enhancement of consumer engagement. Interestingly, the variable “favorites” have a higher impact (beta = 0.834) as compared to the other independent variable. Thus, based on the above discussion, we can accept the hypothesis (H6).

#### **Regression model of Relational Content**

Regression analysis of Facebook was conducted for 884 posts that were hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  for our model were found out to be 0.558 and 0.562, respectively, which shows that the regression model can explain 55% (approx.) of the variance in the data. The F test shows that there is a linear relationship among the variables. The beta value for both the variables is positive and significant, which indicates that they (likes and comments) have a direct impact on the enhancement of consumer engagement. Consequently, we can accept the hypothesis (H7).

Table 4: MLR model for relational content.

Items	Facebook	Instagram	Twitter
Total number of Posts	884	1596	1626
Total number of Likes/Reactions/Favorites	19,95,960	16,46,96,406	32,66,676
Total number of Comments	84,356	5,17,332	1,29,132
Total number of Shares/Re-tweets	1,34,272	-	3,29,454
Adjusted R Square	0.558	0.323	0.798
R Square	0.562	0.326	0.800

For Instagram, regression analysis was conducted for 1596 posts that were hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  for our model are 0.323 and 0.326, respectively, which indicates that the regression model can explain only 32% (approx.) of the variance in the data. Again, the F test shows that there is a linear relationship among the variables. The beta value for the independent variable is positive and significant and thus indicates that there is a direct impact of likes on the engagement of consumers. Therefore, based on the above discussion, we can accept H8.

For Twitter, regression analysis was conducted for 1626 posts that were hosted by Netflix over a period of 12 months. The adjusted  $R^2$  and  $R^2$  for our model are 0.798 and 0.800, respectively, which shows that the regression model can explain 79% (approx.) of the variance in the data. The F test shows that there is a linear relationship among the variables, and the beta values of the independent variables were found out to be positive and significant. Thus, we can say that both the independent variables, i.e., favorites and comments have a direct impact on the enhancement of consumer engagement. Interestingly, between the two independent variables, “favorites” have a higher beta coefficient, which shows that favorites have a higher impact on consumer engagement. Therefore, based on the results and above discussion, we can accept hypothesis (H9).

### DISCUSSIONS AND CONCLUSIONS

Social media marketing is still growing and has become an important aspect of overall marketing strategies formulated by marketers. It is now the need of the hour in almost all the fields of business that helps the business to connect with their consumers on a personal level, build a connection and maintain the relationship. Digital marketing makes it easy for businesses to inform their consumers, attract potential consumers, understand their needs, and cater to them accordingly. Social media marketing is a dynamic and ongoing process that keeps on upgrading and bringing new and trendy techniques to the table. To maintain their place in the industry, it is important for marketers to learn, upgrade and implement digital marketing strategies. OTT platforms have shown significant growth over the years. There has been an increase in new and active users. As people are showing interest in OTT platforms and their content, it is beneficial for them to go over this path and market their platforms to convince the audience to engage more. Now, to enhance this growth, OTT players can use digital marketing practices. This manuscript discovers the impact of social media strategies and content posted by Netflix India on their social networking sites, namely Facebook, Instagram, and Twitter, on the enhancement of consumer engagement. Netflix India has a total of 7,79,90,840 likes on their Facebook page, 5.4 million followers, and 5540 posts on their Instagram page, and 1.3 million followers on their Twitter account. Netflix India is taking benefit of all three contents, namely informational content, promotional content, and relational content.

For Informational content, three social networking sites, Facebook, Instagram, and Twitter, supported all three hypotheses (H1, H2, and H3) and have a positive beta coefficient. Twitter has the maximum number of posts (450) in informational content typology. However, Instagram has the maximum number of Likes/favourites/reactions (6,22,07,928) and comments (1,69,104) in this content typology. For Promotional content, three social networking sites, Facebook, Instagram, and Twitter, supported all the three hypotheses (H4, H5, and H6) and have a positive beta coefficient. Instagram has the maximum number of posts (714) in this content typology. Interestingly, Instagram only has the maximum number of likes/ favourites/ reactions (8,33,11,110) and comments (2,08,542).

For Relational content also all the three social networking sites, Facebook, Instagram, and Twitter supported all the three hypotheses (H7, H8, and H9) and have a positive beta coefficient. Twitter has the maximum number of posts (1626), but Instagram has the maximum number of Likes/Favorites/Reactions (16,46,96,406) and Comments (5,17,332) for this typology.

Regarding the comparison of all the three types of content, relational content came out to be on top as on all the three social networking sites, and relational content has the maximum number of posts and further maximum number of Likes/Favorites/Reactions, Comments and Shares/ Re-tweets.

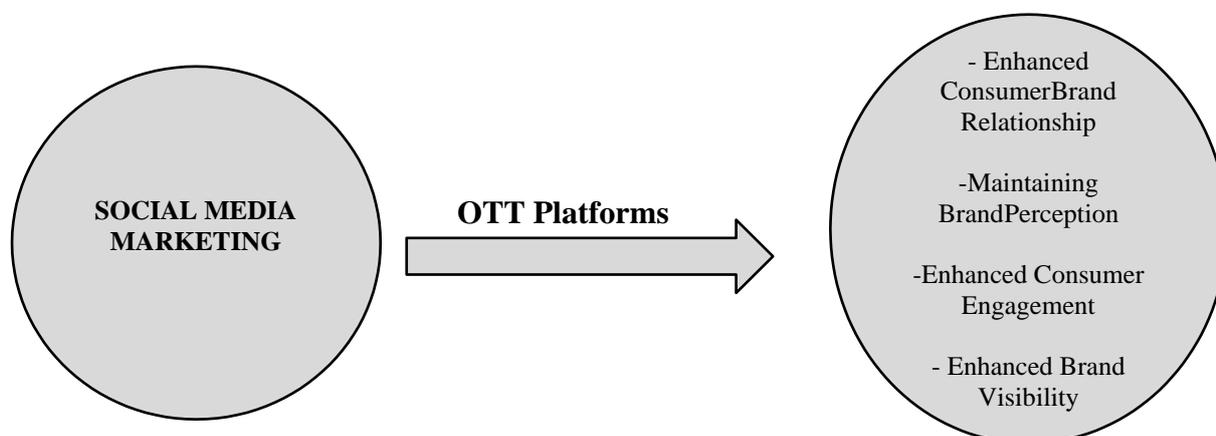


Figure 3: Benefits of social media marketing for OTT platforms.

While this space is growing, and in turn, new content is also getting made and delivered, some challenges are being discovered like attracting the right audience, discoverability of app, and then discoverability of right content on the app. Thus, Netflix India is focusing on innovative ways of marketing to attract the audience to their platforms. Using social media platforms helps a lot in increasing consumer engagement and reach. Social media platforms like Instagram, Facebook, Twitter helps to engage directly with the right audience and expand the reach. The content that Netflix India post on their social media helps the audience to get introduced to new content related to it and build the grounds for sentiments. It helps in creating brand relationships as consumers feel they are connected directly with the brand. Using high-ranked celebrities and influencers to promote the content is also a great strategy as people follow them, and their conversion is comparatively higher.

The limitation of this study is that it does not take into consideration all the factors that may contribute to consumer engagement like paid promotions, paid partnerships, different types of campaigns hosted by the brand, etc. Consumer engagement also includes various other factors such as feedbacks, peer pressure and reviews, brand perception, previous experience with the brand. These are not included in the study.

### MANAGERIAL IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

Marketers are now focused more on digital marketing than traditional marketing and thus shifting much of their funds to digital advertisements. One of the important qualities of digital marketing is that it makes it possible for marketers to quantify their contributions. With the help of analytics, it can easily be interpreted that how much input was done and what and how much the output is. Marketers can also gain insights into how much traffic was directed towards an online campaign. It makes it easier to develop a forecasting model and work accordingly by segmenting the consumers and converting the leads into sales. With the help of social media, it is possible to connect with consumers on a one-to-one basis. It not only informs the consumers about the product but also encourages engagement. Once the consumer engages with the brand positively, he or she also markets the product indirectly. Selecting target audience, creating differentiated content, being consistent helps the businesses to reach more, create more leads, and in turn increase sales. This manuscript has tried to establish a relationship between the content posted by the brand and consumer engagement. It was prominently seen that consumers engage with the content with which they can relate the most. Brands are also taking full leverage of this and posting maximum of relational content so that consumers can feel in sync with the content, relate with it, and in turn engage more. This manuscript is beneficial for marketers as it reflects the importance of social media strategy and content marketing in order to enhance consumers engagement and retain consumers. Social media strategy is the game of insights, analytics, frequency of posts, and quality of content posted by the brand. The main focus of the brand for increasing the engagement should be posting content that interests the consumers, asking questions, respecting their opinions, posting polls in relation with the brands, trying different challenges so that consumers can also participate and co-create the content, etc.

There is very limited research done to date towards how OTT players can use social media marketing practices in order to promote their content and themselves. By conducting research in this area, OTT players can be benefited as they can know which marketing practices are most impactful for increasing viewer reach and engagement, how brand trust and loyalty can be maintained, etc.

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## APPENDIX A: Informational Content

**Table A1: Facebook**

### Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.856 <sup>a</sup>	.733	.726	465.410

a. Predictors: (Constant), Comments, Reactions

### ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41110389.0	2	20555194.5	94.896	<.001 <sup>b</sup>
	Residual	14945849.9	69	216606.521		
	Total	56056238.9	71			

a. Dependent Variables: Shares

b. Predictors: (Constant), Comments, Reactions

### Coefficients<sup>a</sup>

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-135.261	74.998		-1.804	0.76
	Reactions	.038	.057	.122	.665	.508
	Comments	2.355	.585	.740	4.025	<.001

a. Dependent Variables: Shares

**Table A2: Instagram**

<b>Model Summary</b>				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.437 <sup>a</sup>	.191	.179	401.037

a. Predictors: (Constant), Likes

<b>ANOVA<sup>a</sup></b>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2585675.97	1	2585675.97	16.077	<.001 <sup>b</sup>
	Residual	10936494.4	68	160830.800		
	Total	13522170.3	69			

a. Dependent Variable: Comments

b. Predictors: (Constant), Likes

<b>Coefficients<sup>a</sup></b>						
Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	216.544	66.719		3.246	.002
	Likes	.001	.000	.437	4.010	<.001

a. Dependent Variable: Comments

**Table A3: Twitter**

<b>Model Summary</b>				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.873 <sup>a</sup>	.762	.755	582.843

a. Predictors: (Constant), Comments, Favourites

<b>ANOVA<sup>a</sup></b>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	78281287.7	2	39140643.9	115.219	<.001 <sup>b</sup>
	Residual	24458850.7	72	339706.260		
	Total	102740138	74			

a. Dependent Variable: Retweets

b. Predictors: (Constant), Comments, Favourites

<b>Coefficients<sup>a</sup></b>						
Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-120.822	85.055		-1.421	.160
	Favourites	.181	.022	.759	8.393	<.001
	Comments	1.806	1.150	.142	1.571	.121

a. Dependent Variable: Retweets

## APPENDIX B: Promotional Content

Table B1: Facebook

## Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.947 <sup>a</sup>	.896	.893	581.355

a. Predictors: (Constant), Comments, Reactions

ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	212744110	2	106372055	314.735	<.001 <sup>b</sup>
	Residual	24672079.8	73	337973.696		
	Total	237416190	75			

a. Dependent Variable: Shares

b. Predictors: (Constant), Comments, Reactions

Coefficients<sup>a</sup>

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-159.483	71.620		-2.227	.029
	Reactions	.011	.002	.192	4.837	<.001
	Comments	3.128	.143	.870	21.928	<.001

a. Dependent Variable: Shares

Table B2: Instagram

## Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.578 <sup>a</sup>	.334	.329	393.565

a. Predictors: (Constant), Likes

ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9102943.66	1	9102943.66	58.769	<.001 <sup>b</sup>
	Residual	18122526.7	117	154893.390		
	Total	27225470.3	118			

a. Dependent Variable: Comments

b. Predictors: (Constant), Likes

Coefficients<sup>a</sup>

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	81.664	45.332		1.801	.074
	Likes	.002	.000	.578	7.666	<.001

a. Dependent Variable: Comments

**Table B3: Twitter****Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.902 <sup>a</sup>	.814	.810	430.090

a. Predictors: (Constant), Comments, Favourites

**ANOVA<sup>a</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70383631.1	2	35191815.5	190.249	<.001 <sup>b</sup>
	Residual	16093045.4	87	184977.534		
	Total	86476676.5	89			

a. Dependent Variable: Retweets

b. Predictors: (Constant), Comments, Favourites

**Coefficients<sup>a</sup>**

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-199.285	55.050		-3.620	<.001
	Favourites	.243	.015	.834	15.903	<.001
	Comments	1.027	.420	.128	2.446	.016

a. Dependent Variable: Retweets

**APPENDIX C: Relational Content****TableC1: Facebook****Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749 <sup>a</sup>	.562	.558	245.426

a. Predictors: (Constant), Comments, Reactions

**ANOVA<sup>a</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16831321.8	2	8415660.91	139.716	<.001 <sup>b</sup>
	Residual	13131041.6	218	60234.136		
	Total	29962363.4	220			

a. Dependent Variable: Shares

b. Predictors: (Constant), Comments, Reactions

**Coefficients<sup>a</sup>**

Model		Unstandardized B	Coefficients Std. Error	Standardised Coefficients Beta	t	Sig.
1	(Constant)	-13.018	19.393		-.671	.503
	Reactions	.053	.004	.624	12.868	<.001
	Comments	.463	.093	.241	4.972	<.001

a. Dependent Variable: Shares

Table C2: Instagram

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.571 <sup>a</sup>	.326	.323	382.762

a. Predictors: (Constant), Likes

ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18691466.8	1	18691466.8	127.581	<.001 <sup>b</sup>
	Residual	38677853.8	264	146507.022		
	Total	57369320.6	265			

a. Dependent Variable: Comments

c. Predictors: (Constant), Likes

Coefficients <sup>a</sup>						
Model		Unstandardized B	Coefficients Std. Error	Standardised Coefficients Beta	t	Sig.
1	(Constant)	22.348	35.562		.628	.530
	Likes	.003	.000	.571	11.295	<.001

a. Dependent Variable: Comments

Table C3: Twitter

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.894 <sup>a</sup>	.800	.798	327.222

a. Predictors: (Constant), Comments, Favourites

ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	55210692.6	2	27605346.3	534.678	<.001 <sup>b</sup>
	Residual	13836811.5	268	51629.894		
	Total	69047504.1	270			

a. Dependent Variable: Retweets

b. Predictors: (Constant), Comments, Favourites

Coefficients <sup>a</sup>						
Model		Unstandardized B	Coefficients Std. Error	Standardised Coefficients Beta	t	Sig.
1	(Constant)	-153.169	17.735		-8.637	<.001
	Favourites	.163	.005	.852	29.799	<.001
	Comments	.369	.087	.120	4.216	<.001

a. Dependent Variable: Retweets

## A Survey of Cross-Lingual Sentiment Analysis Based on Pre-Trained Models

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### ABSTRACT

With the technology development of natural language processing, many researchers have studied Machine Learning (ML), Deep Learning (DL), monolingual Sentiment Analysis (SA) widely. However, there is not much work on Cross-Lingual SA (CLSA), although it is beneficial when dealing with low resource languages (e.g., Tamil, Malayalam, Hindi, and Arabic). This paper surveys the main challenges and issues of CLSA based on some pre-trained language models and mentions the leading methods to cope with CLSA. In particular, we compare and analyze their pros and cons. Moreover, we summarize the valuable cross-lingual resources and point out the main problems researchers need to solve in the future.

*Keywords:* multilingual, sentiment analysis, pre-trained language models, BERT, GTP.

### INTRODUCTION

The rapid development and popularisation of the Internet inevitably lead to a significant increase in the amount of data (Coffman & Odlyzko, 2002). Moreover, with the massive network texts containing mixed data such as text, audio, and video in various languages, people face complex information.

In particular, SA detects, analyses, and extracts attitudes, opinions, and sentiments expressed by people in a given dataset (Liu & Zhang, 2012; Cambria *et al.*, 2017). SA is a subfield of Natural Language Processing (NLP) (Al-Saqqa & Awajan, 2019), and it is also called opinion mining, orientation analysis, sentiment classification, and subjective analysis. SA tasks involve many NLP problems, including entity recognition, word polarity disambiguation, satire detection, and aspect extraction. The number of issues in a SA task is directly proportional to the difficulties users face in their application.

The SA of online comments needs to consider the sentimental polarity, sentimental intensity, and sentimental polarity analysis. And online sentiment analysis has been applied to many fields to solve different problems, such as understanding the emotions of comments on various social platforms and understanding product reviews to promote product performance (Puranik *et al.*, 2021; Hegde *et al.*, 2021; Yasaswini *et al.*, 2021; Ghanghor *et al.*, 2021). The main task of the research is to identify the subjective attitudes or opinions expressed by people, and the purpose of sentimental intensity analysis is to define the intensity of the commenters' expressions range. Most studies treat SA as a simple classification problem, but SA is a massive suitcase research problem (Cambria *et al.*, 2018). The reason for this is that SA needs to solve many issues in natural language processing, including named entity recognition, word polarity disambiguation, satire detection and aspect extraction. Therefore, each subtask is extremely important and faces unresolved issues. For example, if there are multiple opinion targets for aspect-based SA, the aspect extraction sub-task is ignored, significantly reducing classification accuracy. Therefore, the number of subtasks included in SA tasks is directly proportional to the difficulties they face.

In recent years, with the development of NLP technology, it is gradually applied to various popular fields, such as translation systems, search engines, natural language assistants, and sentiment analysis, and it has also solved many urgent problems in society, which is of great significance (Acheampong, Nunoo-Mensah & Chen, 2021; Yue *et al.*, 2019; Chowdhury, 2003). Especially after combining NLP, ML technology and DL technology for sentiment analysis, monolingual SA research has gradually matured. However, although cross-lingual SA is a unique and essential research direction in SA, there is little work. Moreover, although there have been extensive studies on the polarity of SA, they mainly focus on language with rich resources. English is the most common language in the world. Therefore, most researchers focus on the SA task of English, so they have many ready-made research resources.

On the other hand, research on SA involving Hindi and Arabic is minimal, and the lack of resources has brought problems to researchers, and it has also attracted widespread attention from industry and academia (Yu, 2009). Therefore, to facilitate the research on CLSA, in this paper, we will survey the existing methods for CLSA. CLSA was called multilingual subjective analysis (Banea *et al.*, 2008).

Although there are some surveys on SA, including machine learning-based methods (Sasikala & Sukumaran, 2019), deep learning-based methods (Yadav & Vishwakarma, 2020), and aspect-level SA (Nazir *et al.*, 2020), these surveys are all aimed at SA. Unlike these surveys, in this paper, we survey CLSA based on pre-trained language models. Although some surveys on CLSA (e.g., (Pikuliak, Šimko & Bielikova, 2021)) do not focus on pre-trained model-based methods for CLSA, we do. And they do not include the latest research and techniques since 2019, but we do.

We organise the rest of this paper as follows. The second section briefs CLSA. The third section recaps pre-trained models. The fourth section reviews some cross-lingual pertained model-based methods for CLSA. The fifth section discusses this paper. Finally, the sixth section concludes this paper.

## CROSS-LINGUAL SA

This section will give a general discussion of CLSA.

### Motivation

The lack of reliable language sentiment resources is an important reason for the CLSA task. Sentiment vocabulary includes SentiWordNet (Esuli & Sebastiani, 2006) and MPQA (Blitzer, Dredze & Pereira, 2007). Similar to these public sentiment resources, most of the sentiment resources are English. There are far more sentiment resources in English with annotations than in other languages. This data imbalance problem has led to CLSA, and it is a time-consuming and laborious task to label the sentiment tags of each language manually. Researchers use “borrowing” a rich language resource to another scarce language for SA to solve the problem.

Thus, the problem of CLSA involves the source language and the target language. The source language refers to a language with many research results of SA and rich sentiment resources. The target language is a language with few research results, lacks sentiment resources, or has a few unreliable sentiment resources.

### Main task

Shanahan *et al.* (2004) have explored the use of machine learning and translation technology to mine multiple languages’ views as a pioneering work on CLSA. Specifically, this task first uses the rich source language resources to train the sentiment or opinion classifier, then uses the translation tool to translate the target language into the source language and apply the trained classifier to classify. Finally, it divides the review text among different sentiment polarities. A variant strategy based on this is to first translate the existing knowledge of various language databases into the target language, use the translated resources to train the classifier, and then the classifier analyses the sentiments or opinions of the target language. The difference between the two methods is whether to use the source language or the target language to train and build the classifier. The target language is translated into the source language using the source language; the source language resources are translated into the target language if using the target language.

As an essential topic of text analysis, CLSA uses the source language to assist SA in the target language by establishing a connection between a source language and a target language. Next, we should develop appropriate knowledge transfer methods to use annotation data from the source language to supervised or semi-supervised train the target language’s sentiment classification model. These methods can automatically use and transform knowledge from the source language to generate and expand pseudo-training data in the target language.

### Main methods

Researchers mainly divide CLSA methods into machine translation-based methods (Zhou *et al.*, 2016), machine learning-based methods (Shanahan *et al.*, 2004), structural correspondence learning-based methods (Blitzer, Dredze & Pereira, 2007; Li *et al.*, 2017), transfer learning-based methods (Xu, Xu & Wang, 2011), deep learning-based methods (Dong & De Melo, 2018), and so on. Early researchers mostly used machine translation-based methods and structural correspondence learning-based methods to solve CLSA. However, the in-depth research and practice of ML and DL in NLP brought new ideas to CLSA. As a result, more researchers use machine learning-based methods, transfer learning-based methods, deep learning-based methods, and hybrid methods to solve CLSA problems.

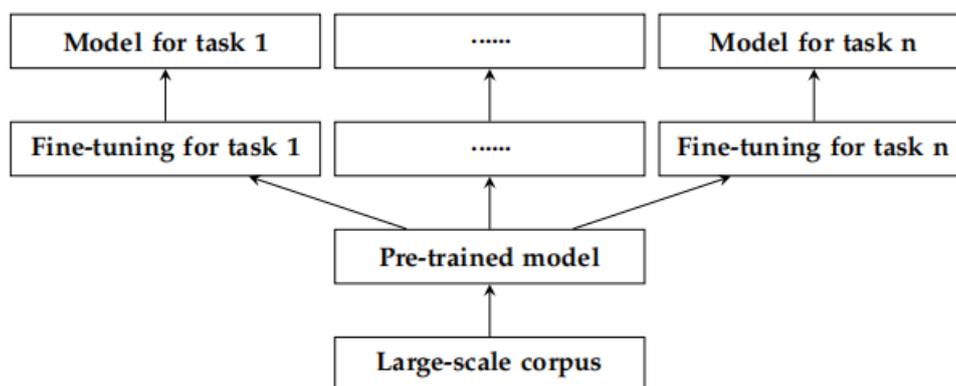
If using learning-based for CLSA, there are mainly three methods for training: (1) Monolingual training and direct conversion: Mikolov, Le, and Sutskever (2013) show that linear transformation can transform the word vector of a source language into the word vector of the target language. For example, when training, we enter a Chinese “angry” word vector; this model can find a word vector that looks similar to English “angry”. When testing, we enter a word vector for “happy” to get a word vector identical to the English one. (2) Monolingual training, respectively, conversion to third-party semantic space: Faruqui and Dyer (2014) do one of the well-known studies. It converts two-word vectors into a third-party space and hopes that the converted Chinese “angry” and converted English “angry” are together in the third-party space. The process of learning this model maximises the similarity between the translated words in our parallel corpus, that is, try to make Chinese “angry” and English “angry” close in the third-party space during the learning process. (3) Bilingual training together: Two representative studies

are (Gouws, Bengio & Corrado, 2015) and (Chandar *et al.*, 2014). The first two methods are performed separately by learning a single-word vector and a bilingual word vector, then find ways to make a relationship between the single-word learned vectors. In short, can we start bilingual learning directly from the beginning? That is to learn the word vector while learning the relationship between bilinguals at the same time. The translated words should be as much as possible, and the not translated words should not matter.

The straightforward way to apply knowledge of one language to another is to use machine translation (such as Google Trans and Yahoo Trans), which can translate the entire corpus into a feasible solution. Language translation is the first step of the machine translation-based method. The second step is to use the Transfer Learning (TL) method (e.g., (Yu & Jiang, 2016)) to transfer the learned knowledge in a source language to a target language for CLSA; TL is a strategy that develops from one language knowledge to another language. However, when applying TL into CLSA, we have to manually select domains to share sentiment words, which may be inefficient.

### Challenges

Researchers have done much work on CLSA, but some unsolved problems still exist. (1) CLSA is to identify the sentiment polarity of the target language by using the sentiment knowledge of the source language. The effective sharing of sentiment knowledge across languages is a considerable challenge for CLSA tasks. Designing reliable sentiment knowledge sharing channels and strategies and constructing beneficial cross-lingual sentiment expression associations are the current research on CLSA. (2) Cross-lingual sentiment knowledge transfer and adaptability, cross-lingual sentiment expression correlation research, and inherent differences in sentiment polarity expression. Some researchers are also committed to studying some resources that can apply CLSA, including datasets (Chakravarthi *et al.*, 2020; Patra, Das & Das, 2018; Priyadarshini *et al.*, 2018), sentiment dictionaries, and bilingual word vectors (Ziser & Reichart, 2018; Kuriyozov, Doval & Gómez-Rodríguez, 2020; Kuriyozov *et al.*, 2019; Chen *et al.*, 2020).



Source: the study.

Figure 1: The process of pre-trained the model.

### PRE-TRAINED MODELS

In this section, we will brief pre-trained models.

Pre-trained models are a new paradigm in NLP (Li *et al.*, 2021). As shown in Figure 1, the pre-trained model is a trained and saved network. The model is previously trained on a large-scale corpus through self-supervised learning. The pre-trained stage used self-supervised knowledge to learn common sense irrelevant to specific tasks from a large corpus; after fine-tuning, the final model is formed. Moreover, pre-trained can be regarded as regularisation to prevent the model from overfitting small data (Erhan *et al.*, 2010).

From 2013 to 2020, the pre-trained model is updated year by year. As early as 2013, Word2vec started the prelude of the pre-trained model, which Mikolov *et al.* (2013) proposed. It is a pre-trained model to generate word vectors. According to the corpus, the optimised training model quickly and effectively expressed a word into vector form. Word2vec is also a word embedding model widely used in emotion analysis, with excellent analysis performance (Alnawas & Arici, 2021). Word2vec has two algorithms for generating word vectors, Skip-Gram (SG) and Continuous Bag-of-Words (CBOW). According to the research of Mikolov *et al.*, SG has good performance in small training data, but CBOW is very efficient, and its accuracy for frequent words is also higher than SG.

Pennington, Socher, and Manning (2014) propose GloVe to overcome Word2vec's defect: it has a low vector dimension and cannot completely contain the data in the corpus. Meanwhile, GloVe takes advantage of the matrix factorisation method and the shallow window-based method. As a result, it can include the local or global information of specific words in the corpus, which is necessary for improving performance. Moreover, it can be more generalised in the process of word embedding than Word2vec.

Bahdanau, Cho, and Bengio (2015) first used the Attention Model (AM) in machine translation, but now it is more and more widely used in the field of NLP (Galassi, Lippi & Torroni, 2020). The first pre-trained model was developed in 2015, combining a mechanism with Long Short-Term Memory (LSTM) (Hochreiter & Schmidhuber, 1997), breaking the limitation that the traditional encoder-decoder structure relies on a fixed-length vector in its encoding and decoding. The AM + LSTM model retains the intermediate output results of the LSTM encoder on the input sequence and then trains a model to selectively learn these inputs and associate the output sequence with the model output.

In 2016, the pre-trained model based on self-attention came into being. Self-attention has another name, internal attention, which is one of the attention mechanisms and has successfully applied to reading comprehension, abstractive summarisation, text implication and learning task-independent sentence representation (Vaswani *et al.*, 2017). For example, word vector feature extraction is usually used in sentiment analysis, while general embedding methods, such as word2vec, need to combine context to clarify the semantics and lose the sequence information of sentences. Self-attention can effectively solve the above problems.

Vaswani *et al.* (2017) propose the Transformer model, which advantage is that it can solve the issues of the slow training speed and low efficiency of the RNN model by using self-attention to achieve a fast parallel effect. In addition, it can dig deep into the characteristics of Deep Neural Networks (DNN) and improve the efficiency and performance of the model. Beginning in 2018, pre-trained models have entered a prosperous stage. As a result, a large number of pre-trained models have emerged to solve various problems. Among them, GPT (Radford *et al.*, 2018), ELMo (Peters *et al.*, 2018), BERT (Devlin *et al.*, 2019), GPT-2 (Radford *et al.*, 2019), and GPT3 (Brown *et al.*, 2020) are typical representatives of pre-trained models.

The pre-trained model can embed common sense with nothing to do with the target task, such as grammatical and semantic knowledge (Su *et al.*, 2021). The pre-trained model can transfer the learned ability to downstream tasks, which solves resource shortages. The pre-trained model supports many NLP tasks, such as natural language understanding and generation tasks (Devlin *et al.*, 2019; Bao *et al.*, 2020; Yang *et al.*, 2019; Dong *et al.*, 2019). The pre-trained model provides scalable solutions for various applications, and it supports new functions that only need to be fine-tuned through task-specific labelled data. The pre-trained model's initial performance is very high, and the speed of performance improvement in the training phase is also breakneck, and the model's fusion is good. The disadvantage is that the pre-trained model needs to meet physical conditions before being used.

### **CROSS-LINGUAL PRE-TRAINED MODELS FOR CLSA**

Typical cross-lingual pre-trained models include BERT, ELMo, ULMFiT, multilingual BERT, XLM-R, and MetaXL. This section will discuss the pre-trained models for CLSA.

#### **Task-specific CLSA model based on BERT**

In bilingual and multilingual countries, Code-Switching is a widespread phenomenon, that is, the use of multiple languages in a single utterance (Priyadarshini *et al.*, 2020; Sitaram *et al.*, 2019; Jose *et al.*, 2020). However, few annotation data sets are available in the Code-Mixed language in the Dravidian language, and there is no way to perform sentiment analysis. Previous work has shown that the BERT-based model achieves the most advanced performance when dealing with SA tasks. To this end, Gupta, Rallabandi and Black (Gupta, Rallabandi & Black, 2021) use BERT (Devlin *et al.*, 2019), mBERT (Devlin *et al.*, 2019), XLM-RoBERTa (Conneau *et al.*, 2020), and TweetEval (Barbieri *et al.*, 2020) for SA on two other code-switched Dravidian languages (Tamil-English and Malayalam English (Chakravarthi *et al.*, 2020)). Their experiments show that task-specific pre-training results in superior zero-shot and supervised performance, better than the performance achieved by leveraging cross-lingual transfer from multilingual BERT models.

Although the model has achieved good performance, its cross-lingual transmission effect on specific data sets is not very good, and the pre-training using cross-lingual and particular tasks does not significantly improve the model's performance, so we can explore how to solve these two problems in the future work.

#### **CLSA model based on ELMo, ULMFiT, and BERT**

Sentiment analysis for English has made significant progress, but due to the sparseness of Japanese and its dependence on large data sets, there are little researches on sentiment analysis for Japanese. Today, the pre-trained transfer model has made significant progress. Therefore, Bataa and Wu (2019) focus on studying whether the existing methods are helpful in Japanese. Based on the idea of TL, they are committed to verifying the effectiveness of ELMo (Peters *et al.*, 2018), ULMFiT (Howard & Ruder, 2018), and BERT (Devlin *et al.*, 2019) in Japanese SA tasks. In their research, the model they fine-tune on the pre-trained model to apply to a specific study is called a TL model. Firstly, they use Japanese Wikipedia4 to pre-train ELMo, ULMFiT, and BERT for comparison under the same pre-trained conditions. The experiment's downstream task is to experiment with Rakuten product review and Yahoo movie review datasets and divide its sentiment polarity into two categories and five ones. The experiment uses the Rakuten product review dataset for pre-trained model comparison research and the Yahoo movie review dataset for ablation research. The purpose of ablation research is to understand better the effectiveness of TL models in Japanese SA. Secondly, they trained ELMo with Biattentiv Classification Network (BCN) and

ULMFiT on the Rakuten product review dataset. The training results show that the error rates of ELMo + BCN and ULMFiT in two and five categories are lower than other non-pre-trained models.

On the Rakuten product review dataset, ULMFiT achieved the lowest error percentages on the second classification task, and BERT achieved the lowest error percentages on the five classification tasks. In addition, BERT achieved the lowest error percentages on the Yahoo movie review dataset's double classification task error percentages. The experimental results show that the method based on TL performs better than the specific task model trained three times the data. ELMo and ULMFiT can also show promising results in the small corpus, which provides a feasible solution to low-resource language SA tasks. However, BERT's training performance on the small-scale training set is lacking. Therefore, if selecting BERT as the migration model, a large amount of training data is still needed for functional SA.

Nevertheless, they prove that TL can effectively solve Japanese SA problems. However, whether these pre-trained models are helpful in other natural language processing tasks is worth studying. In addition, if these models are practical, it is worth discussing whether we can get the same results and conclusions in the future.

### **CLSA model based on Multilingual BERT**

The pre-trained model has made good progress in many English NPL tasks. However, there is a lack of training data in other languages, and the cost of generating new resources for a specific language is too high. Dong and de Melo (2019) propose a self-learning framework based on multilingual BERT to address the issues. Choosing multilingual BERT is that it performs well in the cross-lingual transfer of natural language tasks and can better solve sentiment analysis. It first learns from the available English samples and then predicts the unlabeled non-English samples. The samples with high confidence prediction scores are used as the marking examples for the next fine-tuning iteration until the model can implement cross-lingual tasks. For SA from English to Chinese, on datasets Yelp and Chinese hotel reviews, their experiments show that their model is better than the baseline in terms of accuracy.

In the future, it is worth extending the model by introducing a larger dataset with further fine-grained classification and content analysis.

### **CLSA model based on XLM-R**

The emotions expressed by language may be diverse, but a positive tone can help those who attempt to harm themselves (Chakravarthi, 2020). Therefore, Hossain, Sharif, and Hoque (2021) use pre-trained model XLM-R model for CLSA on comments from the social media platform YouTube with 28,451, 20,198, and 10,705 words in English, Tamil and Malayalam, particularly to identify whether a social media comment or article contains a positive tone. Their experiments show that their XLM-R model outperforms ML and DL baselines in terms of F1-score, precision, and recall as evaluation indicators. In addition, the performance of the XLM-R model is better than all baseline models. In the future, we can also try to integrate context embedding based on sentiment analysis and pre-training models to explore the feasibility of the research.

### **CLSA model based on MetaXL**

The combination of the pre-trained model and TL can effectively solve NPL tasks. However, for monolingual corpora or languages with very low annotation, the effect of transfer learning is not very good, and multi-lingual representation has little correlation between different languages, which is also a big challenge for CLSA. Meta-learning can make the source language learn and transform under the guidance of the target task (Finn, Abbeel & Levine, 2017), and the pre-trained model based on BERT is the most advanced multi-lingual training model at present. Xia *et al.* (2021) propose a MetaXL model combining meta-learning, TL and pre-training, and evaluating the CLSA task model to solve the above problems. The experiment uses Multi-lingual Amazon Reviews Corpus (MARC) (Keung *et al.*, 2020), SentiPers (Hosseini *et al.*, 2018), and Sentiraama (Gangula & Mamidi, 2018) as data sets, English as the source language, and Persian and Telugu as target language. Xia *et al.* use F1-score as an index to evaluate the performance of the model. The experimental results show that MetaXL can effectively transmit representations in other languages. Combined with the pre-trained model, the source language can be closer to the target language, and the model's performance is good.

This model has achieved good performance by placing fewer representation conversion networks on multiple layers of the pre-trained model. In future work, we can study the effect of placing numerous networks on various layers and improving the transfer language performance.

## **DISCUSSION**

Cross-lingual representation has played an essential role in overcoming language barriers in natural language processing. Pre-trained language models have succeeded in lingual classification problems. Therefore, we can view an SA task as an emotion classification problem to deal with pre-trained language models. Although SA tasks use the pre-trained model widely, it does not perform well when a pre-trained model faces aspect-level SA (e.g., fine-grained SA). Applying pre-trained models in fine-grained SA tasks, especially cross-lingual fine-grained SA tasks, is more challenging.

Table 1 compares different cross-lingual pre-trained models for SA, especially their pros and cons. The pre-training results of TweetEval in specific tasks have excellent zero-shot, and we can use supervision performance as a baseline for future research.

However, the cross-lingual transmission effect of this model on particular data sets is not very good. BERT<sub>base</sub> uses TL technology and pre-trained models to solve Japanese sentiment classification and shows the possibility of this work in the future. However, the model does not perform K-fold validation, which may lead to inaccurate performance evaluation. Multilingual BERT improves classification accuracy without target language training data and uses unlabeled text to enhance the cross-language transmission of text classification in SA. Finally, XLM-R has cross-lingual synthesis capabilities at different language levels and performs well, but it cannot reflect the intrinsic meaning of sentences. MetaXL makes the target language and the source language closer in the representation space, with good transmission performance, but it has not yet explored placing multiple conversion networks in various layers of the pre-trained model.

Table 2 compares the performance of various cross-lingual pre-trained models, and Figure 2 displays the comparison against different datasets and each evaluation criterion. For the performance comparison of accuracy, because some models do not use this indicator to evaluate model performance, we do not show the accuracy values of these models in the figure, and the same is true for other performance indicators. As shown in Table 2 and Figure 2, for accuracy, multilingual BERT achieves the best performance, reaching 83.10%; for precision, recall and F1-score, XLM-R achieves the best performance, reaching 0.931; and for error percentage, BERT<sub>base</sub> achieves the best performance, only 4.68%.

Table 1: Cross-lingual pre-trained models for SA.

Reference	Model	Task	Advantage	Disadvantage	Dataset
(Gupta, Rallabandi & Black, 2021)	TweetEval	Task-specific pre-training and cross-lingual transfer for sentiment analysis	Strong pertinence, good performance, can be used as a baseline for future sentiment analysis work	Poor cross-lingual transmission	Tamil-English (Chakravarthi, 2020), Malayalam English (Chakravarthi, 2020), Sentimix Hinglish (Patwa <i>et al.</i> , 2020)
(Bataa & Wu, 2019)	BERT <sub>base</sub>	Japanese sentiment classification	Use TL technology and pre-trained models to solve Japanese sentiment classification	Did not perform K-fold validation	Japanese Rakuten product review binary (Zhang & LeCun, 2017), five class Yahoo datasets
(Dong & de Melo, 2019)	Multilingual BERT	Sentiment classification	Improve classification accuracy without target language training data	No shortcomings for the time being	Yelp and Chinese hotel reviews (Zhang, Zhao & LeCun, 2015), (Chen <i>et al.</i> , 2018)
(Hossain, Sharif & Hoque, 2021)	XLM-R	Multi-classification text sentiment analysis	Have cross-lingual comprehension capabilities at different language levels	Cannot apprehend the inherent meaning of sentences	Hope speech corpus (Chakravarthi & Muralidaran, 2021)
(Xia <i>et al.</i> , 2021)	MetaXL	Multilingual transfer for CLSA	Make the target language and the source language closer in the representation space, with good transmission performance	Have not yet explored placing multiple conversion networks on multiple layers of the pre-trained model	Multi-lingual Amazon Reviews Corpus (MARC) (Keung <i>et al.</i> , 2020), SentiPers (Hosseini <i>et al.</i> , 2018), Sentiraama (Gangula & Mamidi, 2018).

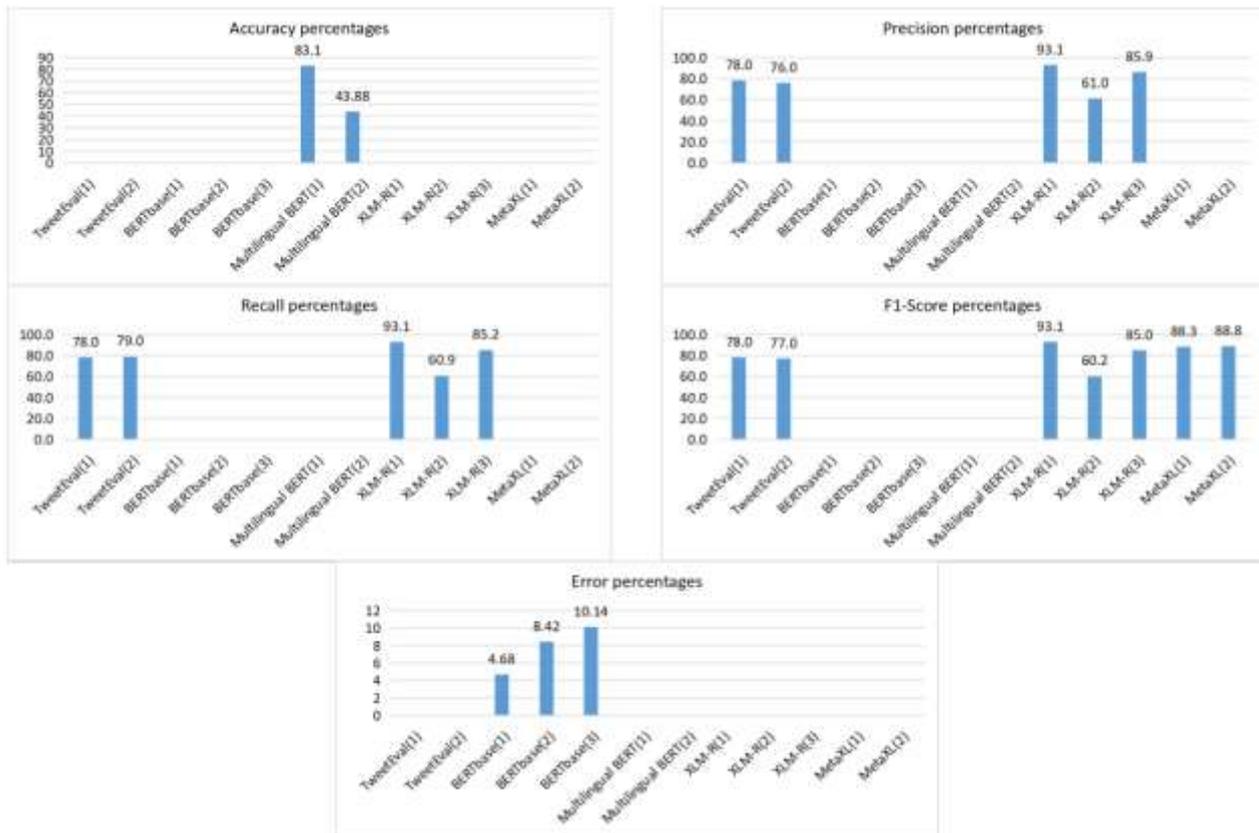
Source: This study.

Table 2: The performance comparison of various cross-lingual pre-trained models for SA.

Reference	Model	Accuracy	Precision	Recall	F1-score	Error
(Gupta, Rallabandi & Black, 2021)	TweetEval(1)	N/A	78%	78%	78%	N/A
(Gupta, Rallabandi & Black, 2021)	TweetEval(2)	N/A	76%	79%	77%	N/A
(Bataa & Wu, 2019)	BERT <sub>base</sub> (1)	N/A	N/A	N/A	N/A	4.68%
(Bataa & Wu, 2019)	BERT <sub>base</sub> (2)	N/A	N/A	N/A	N/A	8.42%
(Bataa & Wu, 2019)	BERT <sub>base</sub> (3)	N/A	N/A	N/A	N/A	10.14%

(Dong & de Melo, 2019)	Multilingual BERT(1)	83.10%	N/A	N/A	N/A	N/A
(Dong & de Melo, 2019)	Multilingual BERT(2)	43.88%	N/A	N/A	N/A	N/A
(Hossain, Sharif & Hoque, 2021)	XLM-R(1)	N/A	93.1%	93.1%	93.1%	N/A
(Hossain, Sharif & Hoque, 2021)	XLM-R(2)	N/A	61.0%	60.9%	60.2%	N/A
(Hossain, Sharif & Hoque, 2021)	XLM-R(3)	N/A	85.9%	85.2%	85.4%	N/A
(Xia <i>et al.</i> , 2021)	MetaXL(1)	N/A	N/A	N/A	88.3%	N/A
(Xia <i>et al.</i> , 2021)	MetaXL(2)	N/A	N/A	N/A	88.8%	N/A

Source: This study.



Source: This study.

Figure 2: The performance comparison of cross-lingual pre-trained models.

## CONCLUSION

CLSA is an essential kind of SA. In this paper, we review the application of pre-trained models in CLSA, compare their similarities and differences, including pros and cons and point out the direction of future improvement. Besides, we also provide some available cross-lingual resources. One of CLSA's future works is the fine-grained CLSA, which is very challenging but significant in practice. Compared with text-based CLSA, multimodal CLSA is also a topic worthy of in-depth study. Besides, pre-trained language models are essential for NLP. Therefore, the application of pre-trained language models to CLSA deserves researchers' more attention.

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## A Survey of Customer Service System Based on Learning

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### ABSTRACT

With the rapid development of artificial intelligence, people have moved from manual customer service to handling affairs, and now they are more inclined to use intelligent customer service systems. The intelligent customer service system is generally a chat robot based on natural language processing, and it is a dialogue system. Therefore, it plays a vital role in many fields, especially in the field of e-commerce. In this article, to help researchers further study the customer service system for e-commerce, we survey the learning-based methods in dialogue understanding, dialogue management and dialogue response generation in the customer service system. In particular, we compare the advantages and disadvantages of these methods and pointed out further research directions.

*Keywords:* E-commerce, customer service system, learning, dialogue understanding, dialogue management, dialogue response generation.

### INTRODUCTION

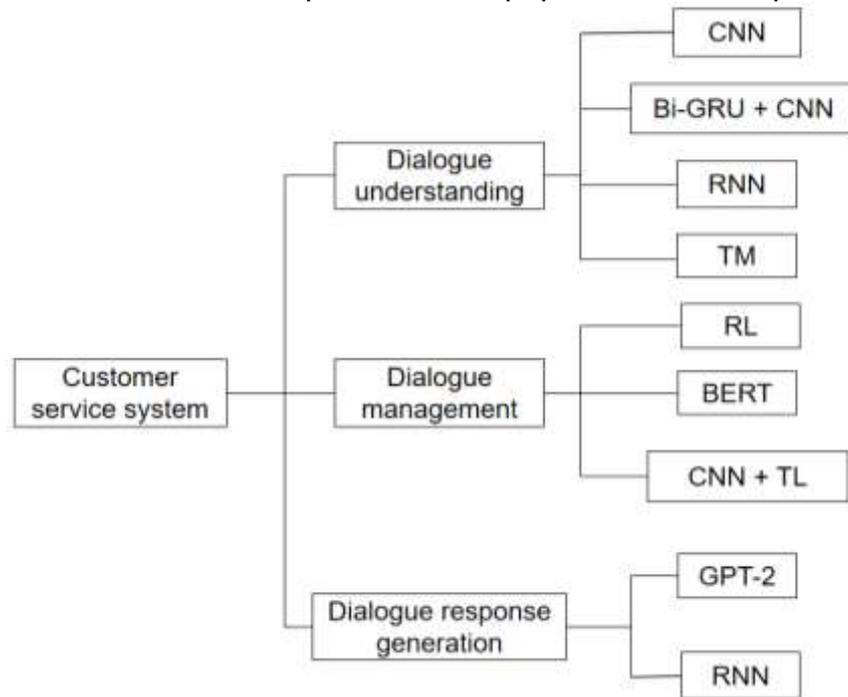
With the rapid development of artificial intelligence and e-commerce, customer service is essential in real life. Customer service refers to manually or non-manually providing customers with pre-sales and after-sales support to help them get a relaxing and pleasant experience. Nowadays, customer service is performed through the phone and e-mail, the Internet, Short Message Service (SMS), social media, and even artificial intelligence technology. If customer service is represented by a computer system or realized by Natural Language Processing (NLP) technology, we call it a customer service system. In the past ten years, many companies have developed self-service intelligent customer service systems, such as AliMe from Alibaba (Li *et al.*, 2017), Google Now from Google (Ehrenbrink, Osman & Möller, 2017), and CarPlay from Apple (Holstein *et al.*, 2015), etc. Customers can talk to them at any time to find the answers they want.

In the field of e-commerce, traditional customer service is primarily manual. In a period of the rapid increase in traffic, such as Taobao's Double Eleven shopping carnival, it will overload the call centre, and manual customer service cannot handle customers quickly and online 24 hours a day. It is also impossible to fully understand the customer's information due to the concurrent needs of the customer, which will reduce the efficiency of customer service to solve the problem, resulting in a long waiting time for customers. Finally, customers are disappointed and dissatisfied with the interactive experience. Research shows that nearly 75% of customers have experienced poor customer service (Siddiqui & Sharma, 2010). Therefore, driven by big data and artificial intelligence technology, merchants are increasingly inclined to use intelligent customer service systems instead of manual customer service to improve their competitiveness in the e-commerce market. The essence of customer service systems is a dialogue system.

A dialogue system mainly consists of three comments: dialogue understanding, dialogue management, and dialogue response generation (Fan, Luo & Lin, 2020a; Fan, Luo & Lin, 2020b; Fan & Luo, 2020). Dialogue understanding aims to convert textual information into a semantic representation that a computer can process. For computers, it is not essential to understand the exact meaning of each word in a sentence. Instead, it is necessary to understand the importance of the sentence. Dialogue management is the core part of the dialogue system. Its primary function is to maintain and update the dialogue's state and give the next dialogue strategy based on the current dialogue state and the knowledge of the knowledge base. Dialogue response management is an integral part of interaction with users. It uses a generative model to generate responses based on the dialogue strategy given by dialogue management to facilitate user interaction. A good generative model can generate sentences suitable for new scenarios by using a small amount of training corpus to provide users with accurate information (Mi *et al.*, 2019).

The existing surveys on the customer service system (Nuruzzaman & Hussain, 2018; Arora, Batra & Singh, 2013; Wang & Yuan, 2016; Chen *et al.*, 2017) are not comprehensive enough, do not involve the latest work in recent years, or are outdated. Therefore, to facilitate people to further study the customer service system, in this paper, we focus on its three essential components: dialogue understanding, dialogue management, and dialogue response generation. Specifically, we will survey the most advanced learning-based methods concentrate on these three aspects. As shown in Figure 1, these methods are Convolutional Neural Network (CNN) (LeCun *et al.*, 1989), Bi- Gate Recurrent Unit (Bi- GRU) (Cho *et al.*, 2014) + CNN, Recurrent Neural Network (Mikolov *et al.*, 2010), Topic Model (Papadimitriou *et al.*, 2000), Reinforcement Learning (RL) (Kaelbling, Littman & Moore, 1996), BERT (Devlin *et al.*, 2018), CNN + Transfer Learning (TL) (Weiss, Khoshgoftaar & Wang) and GPT-2 (Radford *et al.*,

2019). In particular, we compare their pros and cons and point out possible future jobs. We hope that the survey in this paper can provide some clues for customer service developers to choose the proper method for their specific task.



Source: This study

Figure 1: A taxonomy of learning methods used for the customer service system

We organise the rest of this paper as follows. The second section briefs some learning-based methods for dialogue understanding. The third section recaps some learning-based methods for dialogue management. The fourth section reviews some learning-based methods for dialogue response generation. The fifth section discusses this paper. Finally, the sixth section summarises this paper.

## DIALOGUE UNDERSTANDING

### Intent recognition and slot filling

#### *CNN-based method*

To reduce the working load of manual customer service, Li *et al.* (2017) develops an intelligent customer service system, named AliMe, based on CNN for Alibaba the e-commerce platform. It can answer customers' simple, repetitive, and common questions, thus it saves labour costs of an online shopping platform and improves the customers' online shopping experience. So, AliMe is a Question Answering (Q & A) system. To answer the customer's question well, it must recognise the customer's intents through context. AliMe uses CNN for intent recognition of a piece of customer's dialogue (Kim, 2014), and uses fastText (Bojanowski *et al.*, 2017) in the embedding layer of CNN to pre-train the data, and then further fine-tune the training results in the CNN model.

The overall accuracy of AliMe has reached 89.91%, outperforming an SVM based model and an ME based model. It is 7.21% higher than the combination of the SVM model and the ME model.

In the future, it is worth using RL to guide shopping, improve people's online shopping experience, or give AliME the ability to recognize images, and improve the multi-round interaction ability of AliMe to improve human-computer dialogue.

#### *Bi-GRU + CNN-based method*

An essential task of customer service is to perform semantic analysis, including two subtasks: intention recognition and slot filling. To reduce the accumulation of errors caused by the independent modelling of the two subtasks, Wu, Mao, and Feng (2021) propose a model, which integrates deep learning with cloud computing and jointly model CNN, Bi-GRU and CRF to improve the performance of semantic analysis and deploy it in the intelligent dialogue system. First, using two Bi-GRU models to obtain intent classification and slot filling's features, respectively. Then their work uses a CNN model for intent classification, and finally, a CRF model is used to model the slot filling's sequence information.

The experiment uses the ATIS dataset and the PCSF dataset. The first experiment set a different structure for the model on the ATIS data set. After performing ablation experiments, the experimental results show that the accuracy of the proposed model is the best, reaching 89.6%. Then, they carry out the second experiment on the PCSF data set, and other conditions remain unchanged. Again, the experimental results show that the accuracy of the proposed model is the best, reaching 85.6%. Finally, they compare the proposed model with other advanced baseline models on two data sets, and the experimental results show that the proposed model is very effective.

In the future, they will improve the proposed network to process complex sentences to obtain a better user experience. They will also develop a lighter version for the low resource platform so that the model can better serve the common resource platform.

## **Sentiment detection**

### ***RNN-based method***

To track the speaker's status throughout the dialogue process and use this information for sentiment detection, Majumder *et al.* (2019) propose a novel RNN-based model called DialogueRNN. Their model assumes three main aspects related to emotion in the dialogue: the speaker, the context of the previous sentence, and the feeling of the last few sentences. For these three states, DialogueRNN first uses Global GRU to capture the context of a given utterance through dialogue and speaker status, and the speaker's status depends on this context. Then, since the dialogue process is mutual and dynamic, DialogueRNN uses Speaker GRU to update the speaker's emotional state and uses Party GRU to ensure that the model knows the state of the speaker of each utterance. Finally, the updated speaker state is input into the emotion GRU, and the word's emotion representation is decoded, thereby completing sentiment detection.

During the experiment, they use two sentiment detection data sets: IEMOCAP (Busso *et al.*, 2008) and AVEC (Schuller *et al.*, 2012), and divide them into a training set and test set according to the ratio of 8:2. The experiment also compares DialogueRNN with the latest baseline model, using accuracy, F1 score and mean absolute error as evaluation indicators to evaluate the model's performance. Experimental results show that the proposed model is superior to the current state-of-the-art baseline model on both data sets. In addition, the proposed model achieves the best average accuracy values, F1 score and mean absolute error, reaching 63.4%, 62.75%, and 2.102, respectively.

Although their work has achieved the best performance, the proposed model can only perform sentiment detection for a single speaker. In future work, we can extend the current work to perform sentiment detection for multiple speakers.

### ***TM-based method***

The main challenge of sentiment detection in a dialogue system is to classify sentiment types. To obtain comprehensive information from certain types of conversations to improve the performance of sentiment classification, Wang *et al.* (2020) propose a novel Topic-aware Multi-task Learning (TML) based on TM. TML uses three topic models to capture the whole, customer, and agent's topic information to learn the rich discourse representations in customer service conversations. After combining with the context-aware utterance representation obtained after BERT pre-training and context iterative modelling, the sentiment label is finally obtained after gated fusion.

The conversation data set used in the experiment comes from an online customer service system of a top e-commerce company in China, and the experiment uses the Macro-F1 score to evaluate the model's overall performance. The experiment also compared the proposed model with other state-of-the-art baselines. The experimental results show that the proposed TML method is significantly better than the baseline model in terms of performance, with a Macro-F1 score of 75.9%.

It is worth studying to deal with the imbalance problem of emotion classification in customer service dialogue in future work. There are much fewer negative samples in the dialogue dataset than other samples in their work, but in reality, it is sometimes more important to identify negative samples.

## **DIALOGUE MANAGEMENT**

### **Dialogue strategy**

#### ***RL-based method***

To support negotiation between a seller and a buyer, Bagga *et al.* (2020) develop such a system, called ANEGMA, based on deep reinforcement learning. This model can enable agents to conduct bilateral negotiations in an unknown and dynamic electronic market and use multi-thread synchronization to reduce time costs and increase the speed of model operation by using reinforcement learning further to express the strategy of the deep neural network and pre-training the strategy to reduce the learning time in the negotiation process.

Their experiments show that ANEGMA outperforms those with two well-known negotiation strategies in one-to-many contemporaneous bilateral negotiations in different market environments. For example, for the overall performance of the model, in the first experiment of training and testing on conceder time-dependent seller strategy, ANEGMA integrates RL with Supervised Learning (SL) achieves the best performance on  $U_{avg}$  and S%, reaching 0.29 and 87.12, respectively, but on  $T_{avg}$ , the performance of ANEGMA+RL+SL is not so good as that of ANEGMA+RL (67.75s/0.77s). In the second experiment of training and testing on relative tit for tat behaviour dependent seller strategy, ANEGMA+RL+SL achieves the best performance on  $U_{avg}$  and S%, reaching 0.29 and 85.15, respectively, but on  $T_{avg}$ , the performance of ANEGMA+RL+SL is not so good as that of ANEGMA+RL (36.33s/0.76s). For the adaptive performance of the model, in the first experiment of training on relative tit for tat behaviour dependent seller strategy and testing on conceder time-dependent seller strategy, ANEGMA+RL+SL achieves the best performance on  $U_{avg}$  and S%, reaching 0.26 and 86.13, respectively. Still, on  $T_{avg}$ , The performance of ANEGMA+RL+SL is not so good as that of ANEGMA+RL (38.40s/0.74s). In the second experiment of training on conceder time-dependent seller strategy and testing on relative tit for tat behaviour dependent seller strategy, ANEGMA+RL+SL achieves the best performance

on  $U_{avg}$  and  $S\%$ , reaching 0.28 and 84.16, respectively, but on  $T_{avg}$ , the performance of ANEGMA+RL+SL is not so good as that of ANEGMA+RL (19.30s/0.81s).

In the future, it is worth improving ANEGMA in some aspects because the actual market environment is even more complicated than those where ANEGMA works well. So, sellers and buyers are more inclined to do multi-issue negotiation using dynamic strategy in a real market.

### **BERT-based method**

Due to the limitations of the shallow connection of the pre-trained language model, for example, it cannot adapt to dynamic speaking scenarios, weakens the relationship between contexts, and cannot handle sequences composed of a large number of tags. So, to apply BERT to the task of multi-round response selection in e-commerce, Gu *et al.* (2020) propose a novel model called Speaker-Aware BERT (SA-BERT):

- 1) They add speaker embeddings to specific tags to enhance the model so that Speaker-Aware BERT knows the speaker changes during the conversation.
- 2) Since BERT is not good at processing sequences composed of tokens exceeding the limit, they propose a heuristic speaker-perceived disentanglement strategy to solve complex entangled conversations, which helps select a few but the most critical utterances based on speaker information.
- 3) They design domain adaptations to integrate specific domain knowledge into pre-trained language models.

The experiment thoroughly tested the performance of SA-BERT on Ubuntu Dialogue Corpus V1 (Lowe *et al.*, 2015), Ubuntu Dialogue Corpus V2 (Lowe *et al.*, 2017), Douban Conversation Corpus (Wu *et al.*, 2017), E-commerce Dialogue Corpus (Zhang *et al.*, 2018) and DSTC 8-Track 2-Subtask 2 Corpus (Kim *et al.*, 2019), and used recall, mean average precision, mean reciprocal rank, and precision as evaluation indicators. The experiment compares the performance of SA-BERT and the baseline model on the first four data sets. The experimental results show that SA-BERT has the best performance on the four data sets, with average recall reaching 93.28%, 92.43%, 54.70%, and 85.60%, respectively. Furthermore, SA-BERT has the best mean average precision, mean reciprocal rank and precision in Douban Conversation Corpus, reaching 61.90%, 0.659 and 49.60%, respectively. Finally, SA-BERT is used to evaluate the performance of the proposed strategy in DSTC 8-Track 2-Subtask 2 Corpus. The experimental results show that SA-BERT has the best mean reciprocal rank and recall, reaching 0.594 and 47.70%, respectively.

Although their work has achieved the best results on the five data sets, in a horizontal comparison, the proposed model results on Douban Conversation Corpus are much worse than that of Ubuntu Corpus V1 and Ubuntu Corpus V2. Therefore, we can continue to adjust the pre-training language model to adapt to multiple rounds of response selection and design new strategies to achieve better results in future work.

### **Dialogue behavior recognition**

#### **CNN + TL-based method**

To match the best answer in the question-answering knowledge base in the Q & A system, and solve the lack of training data and achieve high Queries Per Second (QPS), Yu *et al.* (2018) propose a CNN + TL model. Researchers roughly divide the CNN-based models that solve Paraphrase Identification (PI) and Natural Language Inference (NLI) problems into two categories, sentence-encoding-based method and sentence interaction-based method. In Yu *et al.* work, they combine the two approaches to capture sentence representation and interaction structure. Make the model reach high QPS to meet industrial needs. At the same time, the TL model is used to obtain labelled data from a resource-rich source domain to a resource-poor target domain and reveals the inter-domain and intra-domain relations. Furthermore, to improve the anti-noise ability of the proposed TL framework, they introduce the positive semi-defined covariance matrix and the adaptive loss function to model the information weight between and within domains.

Their experiments show that compared with other baseline models, the CNN model achieves the best performance in terms of both area under curve and accuracy (*i.e.*, 82.2% and 81.2%, respectively). Moreover, the DRSS model proposed based on the TL method achieves the best performance in both the PI and NLI tasks. So, the performance of the overall model is more efficient than several baseline models, and its performance on six source-target pairs is also better than all existing frameworks. In addition, the framework has been deployed to the online chat system of AliExpress, a cross-border e-commerce platform, significantly improving its performance.

In the future, it is worth improving the model's performance and the transferring ability or learning cross-language chatbots to achieve multilingual services.

## **DIALOGUE RESPONSE GENERATION**

### **GPT-2-based method**

The pre-trained model can generate smooth dialogue responses, but there is still the problem of generating blanks. Existing models (Lian *et al.*, 2019; Kim, Ahn, and Kim, 2020; Roller *et al.*, 2021; Chen *et al.*, 2020; Zhao *et al.*, 2020) generate richer responses by retrieving relevant knowledge from a large corpus and adding dialogue history, but these two methods are time-consuming and labour-intensive. To reduce the retrieval steps and only rely on the generative model to generate dialogue responses, Xu *et al.* (2021) propose a new end-to-end retrieval-free framework based on GPT-2, called KnowExpert. Their work

is to integrate the prior knowledge obtained from unstructured data into the pre-training model with lightweight adapters (Bapna & Firat, 2019) for the first time to get a dialogue response generation model. This method can avoid retrieving the knowledge base, speed up the reasoning time, improve the memory utilization efficiency and significantly improve the generation efficiency of the model.

The experiment uses Wizzard of Wikipedia (WoW) (Dinan *et al.*, 2018) and CMU Document Grounded Conversations (CMU\_DoG) (Zhou, Prabhunoye & Black, 2018) as data sets, compares the proposed model with the baseline model and uses perplexity and F1 score as evaluation indicators to reflect the performance of the model. Experimental results show that on the visible WoW data set, the proposed model has the best perplexity and F1 score, reaching 15.3 and 18.8%. On the other hand, on the invisible WoW data set, the performance of the proposed model is worse than that of the visible WoW data set, reaching 21 and 16.6% in PPL and F1 score. Finally, on CMU\_DoG, the model achieved 17.9 and 12.0% in perplexity and F1 score. In general, the performance of KnowExpert is comparable to the retrieval-based model, indicating that the non-retrieval dialogue generation model has a promising future.

It can be seen from the experimental results that the performance of the proposed model in the visible and invisible domains is quite different. Therefore, studying topic modelling to narrow the performance gap between the visible and invisible domains is worthwhile in future work.

### RNN-based method

Nowadays, many researchers have widely used neural network methods in dialogue response generation, among which the more advanced model is Hierarchical Recurrent Encoder-Decoder (HRED) based on RNN. However, existing work rarely generates informative dialogue responses, so to solve this limitation, Wang *et al.* (2020) extend RNN-based HRED to capture more information content so that the model develops more informative dialogue responses. Their work has followed the three RNNs of HRED. Encoder RNN is mainly used to encode input sentences, and context RNN is used to encode information at the dialogue level, such as the state and intention of the entire dialogue. Finally, the decoder RNN is used for decoding. Moreover, they also expanded the scope of their attention to capturing more information content.

The experiment used two data sets, a preprocessed version of Ubuntu Dialogue Corpus (Serban *et al.*, 2017) and a multi-round dialogue data set collected from Sina Weibo, which from <http://tcci.ccf.org.cn/conference/2018/dldoc/taskline05.pdf>. The experiment uses BLEU and embedding average as indicators to measure the dialogue response generated by the model and compares the proposed model with three baseline models. The experimental results show that the performance of the proposed model is the best on both datasets. The proposed model achieves the best BLEU and embedding average on the Ubuntu dataset, reaching 1.0276 and 0.5716, also in the Weibo dataset, reaching 1.2198 and 0.8260, indicating that the proposed model is effective.

Future work is worth exploring how to better incorporate external knowledge into technical-domain dialogue generation, such as the Ubuntu Troubleshoot scenario.

## DISCUSSION

Table 1: Various methods based on customer service system.

Reference	citation	Method	Issue addressed	Advantage	Disadvantage
(Li <i>et al.</i> , 2017)	69	CNN	Intent recognition and slot filling	Efficient	No explanation
(Wu, Mao & Feng, 2021)	0	Bi-GRU + CNN	Intent recognition and slot filling	Reduce the accumulation of errors	Complicated and large amount of calculation
(Majumder <i>et al.</i> , 2019)	193	RNN	Sentiment detection	Provide better context	Single speaker
(Wang <i>et al.</i> , 2020)	6	TM	Sentiment detection	Get overall information to improve classification performance	Class imbalance
(Bagga <i>et al.</i> , 2020)	6	RL	Dialogue strategy	Efficient	Long exploration time
(Gu <i>et al.</i> , 2020)	36	BERT	Dialogue strategy	Domain adaptation, resolve entangled dialogue, adapt to dynamic environment	Few strategies to resolve entanglement dialogue
(Yu <i>et al.</i> , 2018)	72	CNN + TL	Dialogue behavior recognition	Focus on inter-domain and intra-domain relation	Not easy to converge
(Xu <i>et al.</i> , 2021)	3	GPT-2	Dialogue response generation	Bypass the retrieval process	The performance gap between the domains is large

(Wang <i>et al.</i> , 2020)	0	RNN	Dialogue response generation	Selectively focus on the more semantically important parts of the conversation	Not making better use of external knowledge
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Source: This study.

Table 1 shows several commonly used methods for customer service systems. CNN is often used for text classification to help dialogue systems better perform intent recognition. The advantage of CNN is that it does not need to extract features, which saves feature extraction manually. However, the interpretability of CNN in text classification is poor, so it is not easy to adjust the elements according to the training results. The joint modelling of Bi-GRU and CNN can prevent the accumulation of errors caused by the two subtasks of independent modelling semantic understanding. However, joint modelling will also cause the model to be more complex and generate many calculations. Using RNN for sentiment detection can process each speaker's utterance and consider the speaker's characteristics, which can provide better context to improve the performance of the sentiment detection model. However, this model is currently only for one speaker and cannot be used in the dialogue of multiple speakers. Using TM for sentiment detection can get comprehensive information to improve sentiment classification performance, but this method can still not deal with the class imbalance in sentiment classification. RL is also efficient enough for dialogue systems because it does not require labelling samples, which reduces the costs for manual labelling. However, because RL takes too long to explore the best strategy, it is necessary to use deep learning to accelerate the RL model's convergence speed. The BERT-based method can understand the change information of the speaker, select a small amount of the actual utterances as the filtered context, and perform domain adaptation. However, the model's multi-turn response selection and entanglement strategy are too simple to handle more complex conversations. CNN + TL enables the model to focus on the relationship between source and target domains, rather than just learning the shared feature space between fields. However, the model parameters of TL are not easy to converge. The GPT-2 can bypass the retrieval step in the knowledge base and only rely on the generation model to generate the response, which significantly improves the model's efficiency. However, this method has a significant performance gap between the visible domain and the invisible domain. Finally, the RNN-based dialogue response generation can selectively focus on the more semantically essential parts of the dialogue to generate more reasonable responses. However, this method has not used external knowledge well into dialogue generation.

### SUMMARY

More and more researchers are interested in customer service systems. One of the important reasons is that people's demand for customer service systems in e-commerce and daily life is increasing, and intelligent customer service systems also bring people's lives. Great convenience. In this paper, we survey the learning-based dialogue understanding, dialogue management and dialogue response generation methods. They are the convolutional neural network, Bi-gate recurrent unit + convolutional neural network, recurrent neural network, topic model, reinforcement learning, BERT, convolutional neural network + transfer learning and GPT-2.

In particular, many problems need to be solved in the future. For example, how to use RL to guide shopping, improve people's online shopping experience, give the model the ability to recognise images, and improve the multi-round interaction ability of the model to enhance human-computer dialogue and process complex sentences to obtain a better user experience. Or extend the current work to perform sentiment detection for multiple speakers, adapt to various rounds of response selection, design new strategies to achieve better results, etc.

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## Addressing Wealth Inequality Problem in Blockchain-Enabled Knowledge Community with Reputation-Based Incentive Mechanism

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### ABSTRACT

An increasing number of online knowledge communities have started incorporating the cut-edge FinTech, such as the token-based incentive mechanism running on blockchain, into their ecosystems. However, the improper design of incentive mechanisms may result in reward monopoly, which has been observed to harm the ecosystems of exiting communities. This study is aimed to ensure that the key factors involved in users' reward distribution can truly reflect their contributions to the community so as to increase the equity of wealth distribution. It is one of the first to comprehensively balance a user's historical and current contributions in reward distribution, which has not received sufficient attention from extant research. The simulation analysis demonstrates that the proposed solution of amending the existing incentive mechanism by incorporating a refined reputation indicator significantly increases the equity of rewards distribution and effectively enlarges the cost of achieving reward monopoly.

*Keywords:* Blockchain, knowledge community, wealth inequality, incentive mechanism.

### INTRODUCTION

Online knowledge communities have become increasingly popular for knowledge sharing and communication (Chen, Baird & Straub, 2019; Liu et al., 2020; Rafiei & Kardan, 2015). Famous examples include Quora, Stack Exchange, and Yahoo Answer. However, the lack of an effective incentive mechanism in these communities has led to the decrease of users' enthusiasm to contribute knowledge, and free-riding behaviors have emerged intensively (Kim & Chung, 2018). According to recent statistics, in most knowledge communities, only 1% of users produce original content, 9% of users contribute by synthesizing or curating content, and 90% of users consume content without contributing (Kwon, 2020).

With the development of financial technologies (FinTech), such as blockchain and the token economy, knowledge communities have started embracing these cut-edge technologies to develop precise incentive mechanisms in a decentralized and autonomous manner. Users who post and discover high-quality content and those who contribute to knowledge dissemination can be economically rewarded (Sun et al., 2019). The token-based incentive mechanisms have shown their effectiveness to some level in promoting contributions in knowledge communities. Typical examples include Steemit (<https://steemit.com/>), one of the most popular blockchain-enabled and autonomous knowledge communities.

Regardless of their popularity, blockchain-enabled communities are facing great challenges due to the improper design of their incentive mechanisms. In these communities, as a common form, the voting rights of users are weighted by the tokens they have owned. Such mechanism design is good at increasing the effectiveness of decision-making and promoting user contributions at the early stage of the community. However, as the community evolves, a large number of rewards, as well as voting rights, tend to be obtained by a small number of users, who will monopolize the community. As a result, most ordinary users keep contributing knowledge and voting for good content, but they fail to get the corresponding rewards since the rewards are distributed according to the weights of voting rights. In other words, monopoly turns the community from decentralized towards centralized, seriously harming most users' enthusiasm for the community.

The problem of the current incentive allocation scheme has been identified and highlighted by recent studies, and its seriousness can be easily observed from real-world communities. For example, some scholars have found that the decentralization of blockchain-driven platforms, such as Steemit, Swarm City, Bihu, etc., is far below the ideal level, and the incentive system is abused (Guidi, Michienzi & Ricci, 2020). By analyzing the data collected from Steemit on November 12, 2020, we find that only 0.035% of users controlled over 64% of the voting rights, and this figure is still growing. During December 2020, these powerful users took up 74.8% of the total upvoting rewards in the community, but the percentage of posts they upvoted was less than 1%. Therefore, the distribution of tokens in the community does not effectively reflect the level of knowledge contribution of users, which is of primary concern to us.

Obviously, how to resolve the monopoly of incentive allocation is an urgent issue faced by both academia and communities. However, existing studies in this field mostly focus on detecting and preventing some specific speculative actions for monopolizing rewards, such as using voting bots (Li & Palanisamy, 2019; Guidi & Michienzi, 2020). They fail to address the problem in a more holistic manner by considering how to eliminate the association between the voting weights and the tokens accumulated not from community contributions but from purchasing and renting, which we believe is fundamental and critical. In addition, our focus is not on how to achieve the absolutely equal distribution of wealth, as we cannot deny that there are large discrepancies in the level of knowledge contribution of users in the community. Therefore, to fill in the research gap, in this study, we propose to tackle the problem from the angle of equity theory and incorporate the idea from the reputation system to quantify users' contribution when amending the incentive mechanism. Our main objective is to ensure that the key factors involved in users' reward distribution can truly reflect their contributions to the community so as to increase the equity of wealth distribution.

A simulation analysis based on a real-world dataset collected from Steemit has shown that our proposed solution can reduce the Gini Index of upvoting rewards distribution by 53% and increase the correlation coefficient between users' historical contributions and their upvoting rewards by eight times, without losing the consideration on their current contributions to determining the total rewards of the posts they have upvoted. Moreover, the simulation results also indicate that the proposed solution has created a huge barrier to achieving a rewarding monopoly.

In summary, the novelty and contributions of our work lie in the following: (1) We are among the first to amend the incentive mechanism design in blockchain-enabled knowledge communities by comprehensively considering the trade-off between users' historical and current contributions in reward distribution; (2) We enrich the relevant research of equity theory by expanding its application scenarios to a specific form of Decentralized Autonomous Organizations (DAOs) which has a distinctive character of a strong link between users' property and voting rights; (3) Our validation approach of combining empirical analysis with incentive mechanism simulation based on a real-world dataset collected from Steemit provides implications for the practice of blockchain-enabled incentive mechanism design.

## **RELATED WORK**

This section reviews and discusses related work to our study. First, we summarize the literature on the impact of incentive mechanisms on knowledge contribution that motivates our work. Then, we review the literature on equity theory, which is the theoretical foundation of our work, and its applications on incentive mechanism design. Finally, we discuss some of the recent work on the reputation systems that are the main approach we adopt to solve the problem.

### **Impact of Incentive Mechanism on Knowledge Contribution**

For online knowledge communities, motivation is the key to driving users to participate in knowledge sharing. Motivation theory has been widely used to explain users' online participation behavior (Roberts et al., 2006; Huang et al., 2018). Motivation theory divides motivation into two types, including intrinsic motivation and extrinsic motivation (Ryan & Deci, 2000). To motivate individuals to share their knowledge in online communities, the method of financial rewards is a typical approach (Zhao, Detlor, & Connelly, 2016; Kuang et al., 2019). A great deal of previous research has investigated the influence of external motivation on knowledge contribution. For example, Ryan and Deci (2000) emphasized the importance of external motivation. In their seminal article, they demonstrated that economic rewards provided not only extrinsic motivation but also enhanced intrinsic motivation. Chen, Chang, and Liu (2012) had taken a different approach by focusing on the influence conditions of motivation, incentive mechanism, and satisfaction on knowledge sharing behavior. Their studies had concluded that the incentive mechanism was a significant predictor of the knowledge acquisition motivation of virtual community members.

Overall, these studies indicate that external incentive has a positive effect on enhancing users' willingness to contribute knowledge. Therefore, a proper design of incentive mechanisms in the knowledge community plays an important role in the development of the community. Although these studies have highlighted the importance of economic incentives on knowledge contributions, they have not considered the impact of incentive equity, which is the focus of our work.

### **Application of Equity Theory in Incentive Distribution**

Although economic incentives have been found to have a positive effect on enhancing users' knowledge contribution, some studies have also found that if the distribution of wealth is unequal, it will hinder knowledge sharing, which is related to equity theory. The first systematic study of equity theory was reported by Adams (1963). Equity theory tries to explain people's perception, evaluation, and behavioral judgment of equity. There is a large volume of published studies describing the relationship between the equity of the distribution of economic incentives and the willingness to share knowledge. An empirical study on investigating the motivations behind people's intentions to continue knowledge sharing in open professional virtual communities implied that justice factors appear to be important in leading to higher satisfaction levels (Wolfe & Loraas, 2008; Chiu et al., 2011). Furthermore, Mirkovski et al. (2019) empirically proved that users' sense of equity in obtaining incentives in the community has a moderating effect on the relationship between users' psychological motivation and their willingness to share information.

These studies have summarized the importance of ensuring the equity of incentive distribution to the sustainability of online communities, and they have confirmed the applicability of equity theory in a related context. However, they do not provide any

specific solution to avoid the inequity of incentive distribution, nor do they keep track of the recent development of the blockchain-enabled incentive mechanisms, which is the focus of our work.

### Incentive Distribution Based on Reputation System

To ensure the equity of the incentive distribution of the community, the biggest challenge we face is how to quantify the level of user contribution to the knowledge community. We borrow the idea from the reputation system to formulate our solution. The reputation system is an interactive mechanism, which is the result of a long-term dynamic repeated game of users (Gong & Fan, 2019). A reputation score is an indicator used by the online knowledge community to represent the historical performance of users (Wei, Chen & Zhu, 2015). In recent years, there has been an increasing amount of literature on the combinations of reputation systems and incentive mechanisms. For example, Zhao, Yang, and Li (2012) and Thanasis and George (2010) showed that the establishment of a reputation system based on an incentive mechanism could promote more real feedbacks and, in return, could form a more reliable and trustful reputation system. Gong and Fan (2019) indicated that compared with the incentive model without reputation mechanism, the optimal dynamic model combining the reputation mechanism with the explicit incentive mechanism could not only realize Pareto improvement and increase the incentive intensity, but also improve the level of information sharing efforts in social networking services.

As discussed above, these existing studies have provided both theoretical and empirical supports to our idea of incorporating users' reputations in incentive mechanism design. However, none of them have considered the application of user reputation in increasing community equity. Therefore, our work is aimed to implement a more comprehensive incentive mechanism design that considers users' reputations for addressing the shortcomings caused by an inequity.

## MODEL DESCRIPTION

### Description of Key Variables

In the following, we will identify and introduce the key variables involved in our model, including *Voting Power*, *Weighted Power*, *Vesting Shares*, *Rshares*,  $\Delta t$ ,  $P_{SP}$ ,  $P_{curator}$ .

#### *Voting Power* ( $V_P$ )

*Voting Power* is a variable designed to restrict the abuse of upvoting rights by users in order to maximize their profits. When a user's *Voting Power* is low, his/her votes will carry less influence, resulting in fewer voting rewards. The community recharges a user's *Voting Power* by a maximum of 20% every day, with an upper bound of 100%. The recharge of *Voting Power* starts right after each vote in the following manner:

$$V_P = \min \left\{ V_{P0} + \frac{20\%}{24 \times 60 \times 60} \times t_0, 100\% \right\} \quad (1)$$

where  $V_{P0}$  is the last *Voting Power*.  $t_0$  is the elapsed seconds from the last vote of the curator.

#### *Weighted Power* ( $W_P$ )

*Weighted Power* means a user's level of preference for a post. It can be calculated by Eqs. (2):

$$W_P = V_P \times \frac{|W|}{100\%} \quad (2)$$

where  $W$  is the weight that he/she can set for his/her vote, from 1% to 100%. This weight is positive for upvote and negative for the downvote.

#### *Vesting Shares* ( $V_S$ )

*Vesting Shares* represents the worth of a vote. The value of *Vesting Shares* is not only related to the number of effective *Steem Power* a user holds but also related to the total *Vesting Shares* and total *Steem Power* of the community. It can be calculated as:

$$V_S = \frac{SP}{TV_{fs}} \times TV_S = \frac{SP_1 - SP_2 + SP_3}{TV_{fs}} \times TV_S \quad (3)$$

where  $SP$  is effective *Steem Power* the user holds,  $SP_1$  is the *Steem Power*, the user, holds,  $SP_2$  is the *Steem Power* of outgoing delegation,  $SP_3$  is the *Steem Power* of receiving the delegation,  $TV_S$  is the total *Vesting Shares* of the community, and  $TV_{fs}$  is the total *Steem Power* of the community.

#### *Rshares* ( $RS$ )

*Rshares* reflect a user's contribution to the growth of a post's rewards. It can be positive or negative, depending on whether the user upvotes or downvotes the post. It can be calculated by Eqs. (4):

$$RS = \begin{cases} +V_S \times 10^6 \times \frac{W_{P+c}}{100\%} & \text{for upvote} \\ -V_S \times 10^6 \times \frac{W_{P+c}}{100\%} & \text{for downvote} \end{cases} \quad (4)$$

where  $c$  and  $d$ , which are used to control the decreasing rate of *Weighted Power*, are set to 0.0049 and 50 respectively in Steemit.

### $\Delta t$

$\Delta t$  is a variable designed to reflect the early voting penalties. If curators vote for a post within the first 5 minutes after the post is created, a certain portion of their rewards will be deducted and sent to the author.

$$\Delta t = \begin{cases} \frac{t}{5} & \text{for } t < 5min \\ 1 & \text{for } t \geq 5min \end{cases} \quad (5)$$

where  $t$  is the time of upvote after posting,  $\Delta t$  is the portion of their curation reward that remained for the curator.

### $P_{SP}$

$$P_{SP} = \frac{RS_T}{R_c} \times R_b \quad (6)$$

where  $P_{SP}$  is the total payout of the post,  $RS_T$  is the total *Rshares*,  $R_b$  is the reward balance of the community, and  $R_c$  is the recent claims, i.e., the total *Rshares* of all posts that have not been settled yet.

### $P_{curator}$

$P_{curator}$  is the reward for a single curator. Up to 50% of the total payout is awarded to curators who upvote the post as a reward for discovering the content. The remaining 50% is awarded to the authors. Eqs. (7) is the original upvoting reward distribution scheme.

$$P_{curator} = 0.5 \times RS_T \times \frac{R_b}{R_c} \times \frac{\frac{RS'+RS}{\sqrt{RS'+RS+2s}} \cdot \frac{RS'}{\sqrt{RS'+2s}}}{\frac{RS_T}{\sqrt{RS_T+2s}}} \times \Delta t \quad (7)$$

where  $RS'$  is the *Rshares* accumulated by the post before the curator votes,  $s$  equals  $2 \times 10^{12}$  in Steemit.

## Model Construction

In Steemit, Steem Power is similar to equity in a company, which reflects how much influence a user has in the community. Holders of Steem Power can not only receive dividends but also influence the value of posts. However, *Steem Power* is not a good indicator for users' past contribution since users can acquire a large amount of *Steem Power* in a short time through leasing or purchasing. *Steem Power* soon becomes the key factor of causing upvoting reward monopoly. Based on this, one might reckon that the simplest solution would be to remove purchased/rented tokens from the incentive system. However, as a cryptocurrency, the free exchange in the market is one of the basic characteristics of tokens, so it is not reasonable to do that. From another perspective, this study is aimed to alleviate the inequality of community upvoting rewards distribution indicated by the *Gini Index*, and at the same time, to balance users' historical contributions and their current contribution to determining the total rewards of the post, respectively, when distributing the upvoting rewards.

In order to achieve the above objectives, we need to introduce more variables to indicate the aspects being considered in upvoting reward distribution. First of all, the reputation system of the community plays an important role in promoting user participation in knowledge-sharing activities by quantifying users' past contributions to the community, which can fulfill our requirements. Therefore, the first main amendment of the upvoting rewards is to incorporate a user reputation indicator. However, the total rewards for the author of a post and all the curators who upvote this post are determined by the *Rshares* of these curators. In other words, the *Rshares* of a curator indicates his/her current contributions to the total rewards of a post. A curator's *Rshares* should not be totally ignored when distributing the rewards. Otherwise, it will badly harm fairness and will lower users' willingness to upvote a post. Therefore, by making a tradeoff, we propose to incorporate both the reputation indicator and the *Rshares* of users, reflected as their corresponding proportions, into the upvoting reward calculation. The proportions are determined in an experimental way that will be introduced later.

The detailed amended upvoting reward calculation is illustrated in Algorithm 1. Specifically, a curator's upvoting reward for a post will be calculated by two steps: (1) Calculate the total rewards for this post upon Eqs. (1-6); (2) Calculate the specific reward that can be allocated to the curator. Our upvoting reward amendments are made upon Eqs. (7) which is the original upvoting reward distribution scheme of Steemit. Firstly, we split the total rewards into two parts. One part is for the users' historical contribution indicated by their reputation, and the remaining part is for their current contribution indicated by their *Rshares*. We

define a new variable  $PR \in [0, 100\%]$ , i.e., the proportion of reputation reward, to control the proportion of rewards assigned to the reputation aspect, and then  $1 - PR$  indicates the proportion of rewards assigned to the *Rshares* aspect.

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**Algorithm 1: Optimized upvoting reward distribution algorithm**

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Input: the total votes of the post  $N$ , the serial number of the curator  $i$ , the proportion of reputation reward  $PR$ ,  $VP_i, W_i, SP_i, TV_s, TV_{fs}, R_b, R_c, \Delta t_i, H \in \{0, 1\}$ , the reputation score of the curator  $RU_i$ .

Output: Upvoting reward of the curator  $P_{\text{curator } i}$ .

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1:  $RS_T \leftarrow 0$ ;  $RS' \leftarrow 0$ ;  $RS_0 \leftarrow 0$ ;  $RD_T \leftarrow 0$ ;  $RD' \leftarrow 0$ ;  $RD_0 \leftarrow 0$ ;
2: for all  $i \in [1, N]$  do
3:    $WP_i = VP_i * |W_i|$ ;
4:    $VS_i = SP_i * TV_s / TV_{fs}$ ;
5:   if  $H=0$  // upvote
6:      $RS_i = + VS_i * 10^6 * (WP_i + 0.49\%) / 50$ ;
7:   else // downvote
8:      $RS_i = - VS_i * 10^6 * (WP_i + 0.49\%) / 50$ ;
9:   if  $RU_i \leq 25$ 
10:     $RD_i = 0$ ;
11:   else
12:     $RD_i = RU_i * (RU_i - 25)$ ; // the reputation indicator of the curator  $i$ 
13:   for all  $j \in [1, N]$  do
14:     $RS_T \leftarrow RS_T + RS_j$ ; // the total Rshares of the post after a week
15:     $RD_T \leftarrow RD_T + RD_j$ ; // the total RD of curators who upvote the post after a week
16:   for all  $k \in [0, i-1]$  do
17:     $RS' \leftarrow RS' + RS_k$ ; // the total Rshares accumulated by the post before the curator  $i$  votes
18:     $RD' \leftarrow RD' + RD_k$ ; // the total RD of curators before the curator  $i$  votes
19:     $P_{sp} = RS_T * R_b / R_c$ ;
20:     $WS = ((RS' + RS_i) / \sqrt{RS' + RS_i + 2s}) - RS' / \sqrt{RS' + 2s}) / (RS_T / \sqrt{RS_T + 2s})$ ;
21:     $WD = ((RD' + RD_i) / \sqrt{RD' + RD_i + 2s}) - RD' / \sqrt{RD' + 2s}) / (RD_T / \sqrt{RD_T + 2s})$ ;
22:     $P_{\text{curator } i} = 0.5 * P_{sp} * (WS * (1 - PR) + WD * PR) * \Delta t_i$ ;
23:   return ( $P_{\text{curator } i}$ );
24:   end if
25:   end for
26: end for

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To determine the reputation reward, the main problem that we need to deal with is how to design a suitable reputation indicator for reward distribution. To quantify a user's historical contributions, Steemit uses a variable *Reputation Number* that is directly correlated with the user's *Rshares* received by users for their posts and comments, as is shown in Eqs. (8), to address the wide-range problem of the *Reputation Number*, Steemit applies a logarithm transformation to generate a new indicator  $RU$ . But it goes from one extreme to the other, making the difference of reputation among users very tiny so that it cannot significantly differentiate the users' historical contributions. With this regard, this study defines a new variable, reputation indicator  $RD$  in Eqs. (9). Through this nonlinear relationship, the historical contribution level of users can be reflected more reasonably. The effectiveness analysis of this part of improvement will be further discussed later.

$$RU = (\log^{\text{Reputation Number}} - a) \times b + \text{Initial Score} \quad (8)$$

$$RD = RU \times (RU - \text{Initial Score}) \quad (9)$$

Where  $RU$  represents the user's reputation score,  $a$  and  $b$ , which are used for controlling the growth rate of  $RU$ , are both set to 9 in Steemit. *Initial Score* is the user's initial reputation score. Steemit sets the *Initial Score* to 25. When  $RU$  is lower than the initial reputation score of 25,  $RD=0$ , indicating that the user does not contribute to the community.

The next problem is how to distribute rewards among all the curators who upvoted the same post. The proposed allocation method is similar to Steemit's original calculation method in Eqs. (7), which adopts upvoting rewards gradually declining with upvoting time. The main difference is that the reputation part needs to be taken into account. Specifically, two nonlinear formulas of  $WD$  and  $WS$  in Algorithm 1 are respectively used in this paper to represent the reputation indicator  $RD$  of the curator and the *Rshares* of his/her contribution to participate in the income distribution. Where,  $RS'$  represents the total *Rshares* contained in a post before the curator  $i$  upvotes the post;  $RS_i$  means that the *Rshares* contributed by the curator  $i$ ;  $s$  is a constant, is equal to  $2 \times 10^{12}$ ;  $RD_T$  represents the total reputation indicator  $RD$  of all the curators of the post;  $RD'$  means that the total  $RD$  contained in the post

before the curator  $i$  upvotes the post;  $RD_i$  represents  $RD$  contributed by the curator  $i$ ; Thus, the upvoting reward  $P_{curator}$  of each curator in the post can be calculated.

### SIMULATION RESULT

This section will first describe how to determine the proper value of  $PR$ , *i.e.*, the proportion of rewards assigned to the newly introduced reputation indicator based on simulation analysis. Generally, the value of  $PR$  is determined by making a tradeoff between the equity of reward distribution and the importance attached to users' historical and current contributions. Furthermore, we will report the assessment results on the effectiveness of the proposed solution by comparing the equity distribution and the cost to achieve reward monopoly before and after the amendment.

We use the distributional equality metric *Gini Index* (Wang et al., 2020) to measure the equality of the upvoting rewards distribution in the community. *Gini Index* is defined as:

$$Gini\ Index = \frac{\sum_{i=1}^n \sum_{j=1}^n |P_{curator_i} - P_{curator_j}|}{2n^2\bar{x}} \quad (10)$$

where  $P_{curator_i}$  is the upvoting reward of user  $i$  ( $i \in [1, 2, \dots, n]$ ).  $P_{curator_j}$  is the upvoting reward of user  $j$  ( $j \in [1, 2, \dots, n]$ ).  $\bar{x}$  is the average absolute difference of the upvoting reward of all users. A lower *Gini Index* indicates greater equality, with 0 representing perfect equality.

To quantify the real influence of users' historical and current contributions on reward distribution, we use  $R(RS, P_{SP})$  ( $0 \leq R(RS, P_{SP}) \leq 1$ ) to denote the correlation coefficient (Fieller, Hartley & Pearson, 1957) between users' *Rshares*, *i.e.*, their current contributions to determining the total rewards of a post, and their own upvoting rewards  $P_{SP}$ :

$$R(RS, P_{SP}) = \frac{cov(RS, P_{SP})}{\sqrt{var(RS) \times var(P_{SP})}} \quad (11)$$

where  $R(RS, P_{SP})$  is the correlation coefficient between the users' *Rshares* and their own upvoting rewards  $P_{SP}$ .  $cov(RS, P_{SP})$  represents the covariance between the users' *Rshares* and their own upvoting rewards.  $var(RS)$  and  $var(P_{SP})$  represent the variance of the users' *Rshares* and their own upvoting rewards, respectively.

Similarly, we use  $R(RD, P_{SP})$  ( $0 \leq R(RD, P_{SP}) \leq 1$ ) to denote the correlation coefficient between users' historical contribution and their upvoting rewards.

### Dataset

We collected the ten posts in the popular list on November 22, 2020, in Steemit randomly, as shown in Table 1 below. These posts received a total of 494 upvotes.

Table 1: Data statistics

Statistic	Average	Standard Deviation	Minimum	Maximum
Number of upvotes of the post	49.4	16.0	20.0	71.0
Post rewards/Steem Power	87.2	48.8	25.0	195.5
Author rewards/Steem Power	45.2	25.1	12.5	97.9
Curator rewards/Steem Power	0.8	5.0	0.0	74.6
Reputation score	56.9	16.3	-0.9	80.7
Number of effective Steem Power of curator	113941.7	784306.9	0.0	10094907.0

### Equity of Reward Distribution

Based on the above dataset, we can obtain the correlation coefficient between users' historical contribution and their upvoting rewards  $R(RD, P_{SP}) = 0.07$ , the correlation coefficient between the users' *Rshares* and their own upvoting rewards  $R(RS, P_{SP}) = 0.98$  and *Gini Index* = 0.95 before the upcoming reward amendment. The high *Gini Index* indicates that the current inequity level of upvoting reward distribution is extremely high in the community. Moreover, the unbalanced values between  $R(RD, P_{SP})$  and  $R(RS, P_{SP})$  confirm that the upvoting reward distribution is mostly determined by the users' current *Rshares*, which can be easily obtained through purchasing or renting, but has little to do with their past contributions.

In order to achieve the target that the upvoting rewards distribution of the posts can truly reflect users' contributions, we incorporate a refined reputation indicator  $RD$  into the upvoting incentive distribution scheme. Figure 1 depicts the results of comparing the correlation coefficients between the reputation and rewards when using the proposed indicator  $RD$  and the original indicator  $RU$  respectively, under different proportions of reputation reward  $PR$ . The results show that the proposed  $RD$  is able to enlarge the correlation coefficient between reputation and rewards, which is consistent with our expectation and validates the design of the  $RD$  indicator.

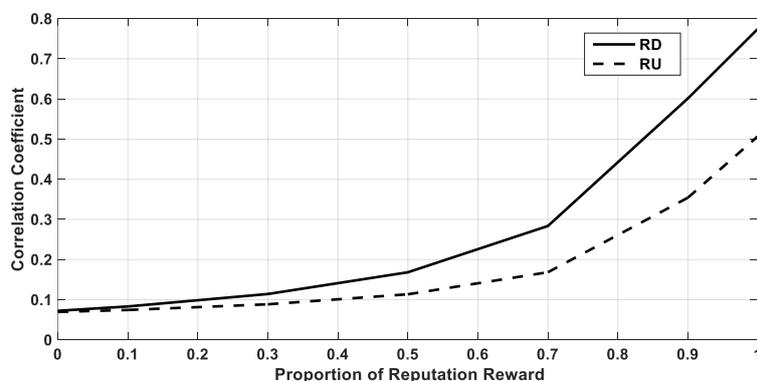


Figure 1: Comparison of reputation-reward correlation coefficients using  $RD$  and  $RU$

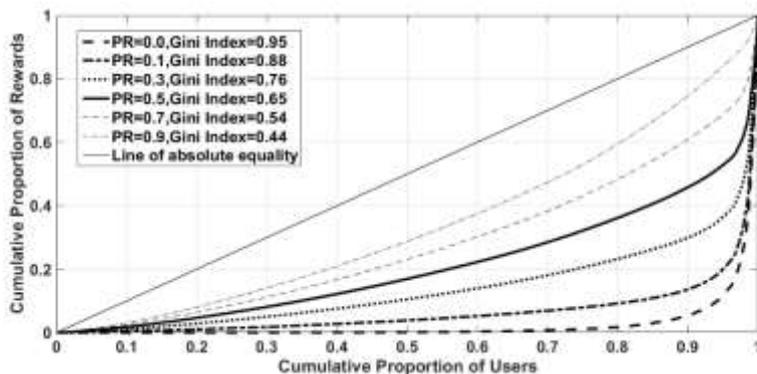


Figure 2: Lorenz curves and  $Gini$  index with different  $PR$  values

Figure 2 shows the Lorenz curves and their corresponding  $Gini$  Index when different proportions of reputation rewards  $PR$  are set. It can be seen from the results that when more proportions of rewards  $PR$  are allocated to the reputation aspect, the inequity level of reward distribution decreases dramatically. Such results demonstrate the effectiveness of our proposed amendment by considering the reputation aspect.

However, it should be noted that achieving absolute equity is not the ideal situation. As mentioned earlier, besides considering users' historical contributions to the community, we should also differentiate each user's efforts in determining the total rewards of a post so that they could be effectively motivated to upvote high-quality content. Although a more comprehensive mechanism of how to make a trade-off between a user's historical and current contributions can be further discussed, to simplify the analysis, here we assume that a user's historical and current contributions are equally important. Following this assumption, we aim to find an equilibrium point of the correlation coefficient between users' historical contribution and their upvoting rewards  $R(RD, P_{SP})$  and the correlation coefficient between the users'  $R$ shares and their own upvoting rewards  $R(RS, P_{SP})$  by varying the proportion of reputation reward  $PR$ , and the results are depicted in Figure 3. It is intuitive that  $R(RD, P_{SP})$  increases while  $R(RS, P_{SP})$  decreases along with the increase of  $PR$  in a non-linear manner. When the proportion of reputation reward  $PR = 0.89$ , the equilibrium point can be found and  $R(RD, P_{SP}) = R(RS, P_{SP}) = 0.58$ , and  $Gini$  Index = 0.44. In the following analyses, we keep the same setting that  $PR=0.89$ .

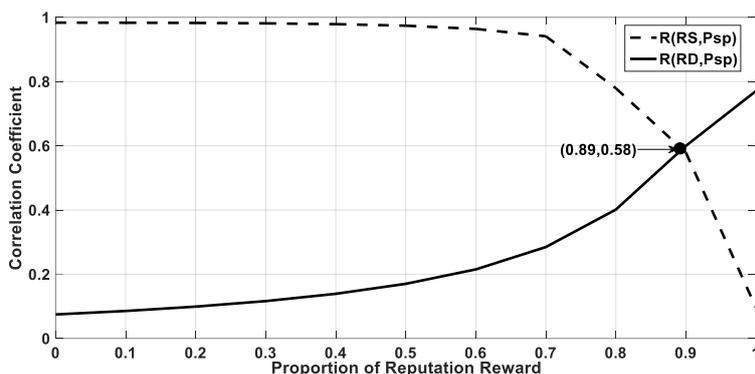
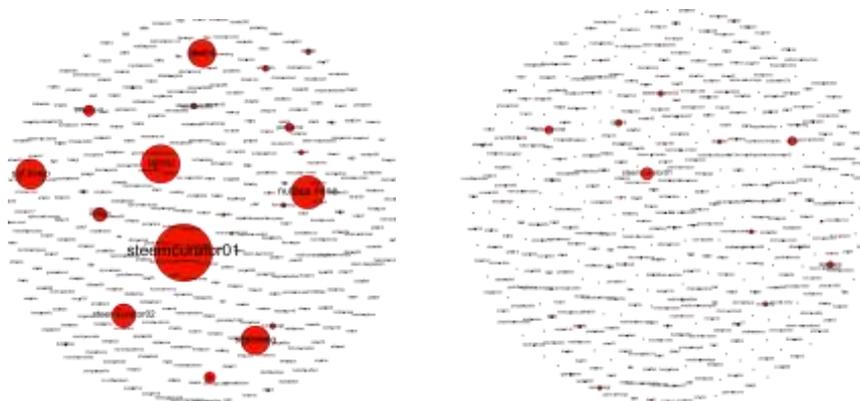


Figure 3: The equilibrium between  $R(RD, P_{SP})$  and  $R(RS, P_{SP})$

Figure 4 compares the users' upvoting reward distributions of the 494 users in our dataset before and after the amendment. It can be seen from the figure that the upvoting reward distribution of the community becomes more equal after introducing the proposed reputation indicator, although we still give weights to the users' current contributions indicated by their *Rshares*.



(a) Before amendment (b) After amendment

Figure 4: Distribution of rewards for upvoting

**Cost of Monopoly**

The above analysis has demonstrated the effectiveness of our proposed amendment in addressing the inequality problem of upvoting reward distribution. To further assess the capability of the proposed solution in resisting upvoting reward monopoly, in this section, we evaluate and compare the costs that a user has to pay in order to achieve monopoly before and after the amendment.

Following Avin et al. (2019), we regard obtaining 50% of a post's total upvoting rewards as a monopoly of upvoting rewards, and we then analyze the efforts a user should make to achieve such status by assuming 20 active users are voting together on a post. Here we define active users as those who post, comment, or upvote at least once a month. Statistical analysis of historical data shows that the average reputation indicator *RD* of active users is around 350, and their average amount of *Steem Power* them is around 1000. We set the *RD* and *Steem Power* of the 20 simulated users to the two average values.

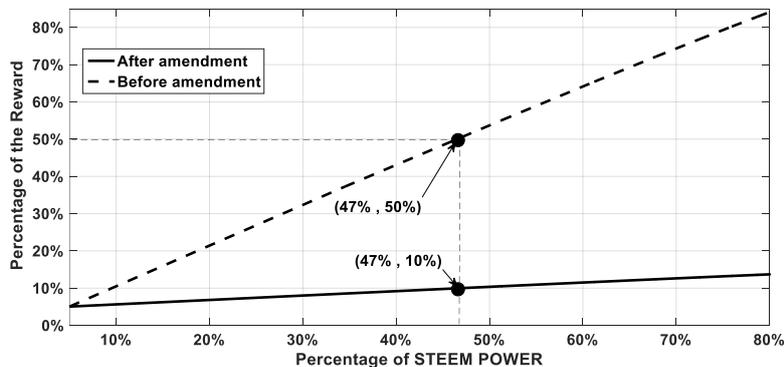


Figure 5: The impact of increasing the percentage of *Steem Power* on the upvoting reward distribution

We simulate two simple strategies a user may adopt to achieve monopoly. One is the reputation of the user remains the same, and he/she gains control over reward distributions purely by accumulating *Steem Power*. As is shown in Figure 5, with the original incentive mechanism, this user can get 50% of the upvoting rewards of the post if the proportion of his/her *Steem Power* reaches 47% of the total *Steem Power* of all users who upvoted the post. After the amendment, even this user controls 47% of the total *Steem Power*, and he can get only 10% of the total rewards. Overall, it can be seen that after the amendment, with the accumulation of *Steem Power*, the control power over reward distribution does not increase significantly. In other words, our proposed amendment has effectively increased the cost and set the barriers for achieving a monopoly.

On the contrary, the other strategy is that a user may achieve monopoly by purely accumulating reputation rather than *Steem Power*. The reputation of a user is a reflection of the *Rshares* he/she has obtained by posting and receiving upvotes from other users. In order to increase the reputation value, the user should make other users with sufficient *Rshares* upvote his/her own posts in a short time through bribery. The cost a user should pay to lift his/her reputation can be measured by the total *Steem Power* of those users under his/her control. Figure 6 depicts the relationship between the percentage of controlled *Steem Power* of the community by a user and the percentage of rewards he/she can obtain through lifting his/her reputation value. It can be seen from the results that the cost of lifting a user's reputation value is extremely large. Even in an extreme case that a user could make every other user upvote his post in order to lift his reputation, he/she could only obtain less than 30% of the upvoting rewards. Considering the huge costs, it is obviously uneconomical to pursue a monopoly through accumulating reputation. In this aspect, the effectiveness of the proposed reputation-based incentive mechanism can be further verified.

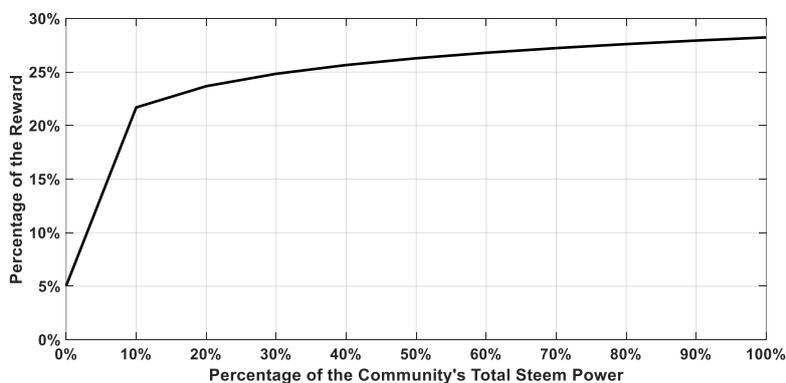


Figure 6: The impact of improving reputation indicator *RD* on the upvoting reward distribution

## CONCLUSION

The incentive mechanism based on tokens plays an important role in the blockchain knowledge communities. However, if the incentive mechanism design is not reasonable, a large proportion of rewards may be monopolized by a small number of users, and the platform will tend to be centralized. Moreover, most ordinary users keep contributing knowledge, but they fail to get the corresponding payoff so that their sense of unfairness increases and their enthusiasm to contribute knowledge declines. This is a general phenomenon in blockchain-driven platforms, which has been mentioned by several scholars (Beck, Müller-Bloch & King, 2018; Li & Palanisamy, 2019; Wang et al., 2020). Steemit is one such typical case. This study has found that the existing incentive mechanism in Steemit can reflect the users' contributions to the growth of a post's total rewards, but such contributions can be largely related to the tokens purchased or rented from the external market and fail to reveal the users' real knowledge contributions to the community.

In order to address this problem, we take into account the users' historical performance in knowledge creation and dissemination without ignoring their contributions to the growth of the posts' rewards. By taking a tradeoff, we find the optimal proportion of rewards allocated to the reputation aspect that reflects a user's historical contributions. The simulation results show that our proposed solution can reduce the *Gini Index* of upvoting rewards distribution by 53% and increase the correlation coefficient between user's historical performance and reward by eight times. In addition, we also analyze the costs that a user needs to pay if he/she wants to monopolize the distribution of upvoting rewards. The simulation results indicate that after implementing the proposed amendment to the incentive mechanism, it becomes infeasible to achieve upvoting reward monopoly by accumulating either *Rshares* or reputation values.

However, due to the incompleteness of data and simplified research methodology, there are still several limitations of this work that are worth mentioning. First, this study only constructs a static upvoting reward simulation model. Future work may attempt to build more complex dynamic network models, which will be helpful to depict the behavior of users more accurately. Second, the dataset used in this simulation model contains only 500 users. Subsequent studies can try a larger user sample to verify the effectiveness of the proposed solution. Third, we amend the incentive mechanism of the community by introducing the reputation system, with the assumption that the reputation system is not abused in the long run. However, this assumption may be violated with some speculative strategies, which may need further investigations.

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## **An Analysis on the Formation and Cultivation of Environmental Protection Norms in the Context of Green Gamification**

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### **ABSTRACT**

Currently, individual green behaviors have attracted great attention from many countries for environmental degradation. It is particularly critical to identify useful strategies to motivate users' green behaviors. Based on the goal framing theory, this paper considers three target motivations (hedonic goal, gain goal, and normative goal) of users' behaviors, proposes the formation and cultivation mechanics of green behaviors in the green gamification platform, and builds a model considering the process of users' engagement. By comparing users' quality situation (high, general, low), this paper concludes that a lower involvement degree is required by high-quality individuals when forming and cultivating an environmental behavior habit. The result also benefits organizations that apply gamification designs in varieties of ways to engage and steer users like employees or consumers toward targeted goals.

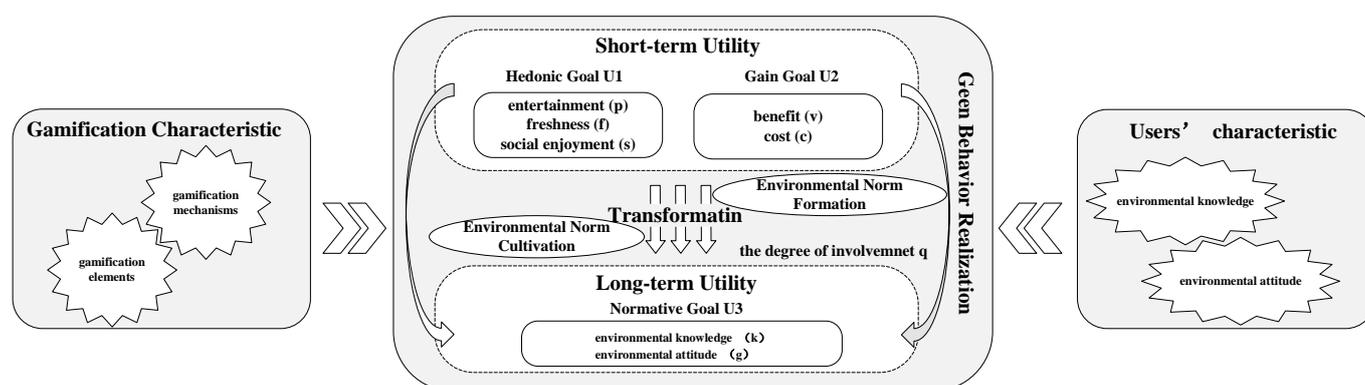
*Keywords:* Environmental behaviors, formation, cultivation, green gamification, goal framing theory.

### **INTRODUCTION**

Recently, there have been many initiatives to promote environmental protection for the increasingly prominent environmental issue (Yang, Chen, & Zhang, 2020). Carbon footprint reduction is the holy grail of our times, and it can achieve through prudent energy consumption. However, the end-consumer is still the weakest link of energy conservation (Papaioannou, Hatzi, & Koutsopoulos, 2018). Nowadays, green e-commerce applications using gamification are emerging. For example, Alipay "Ant Forest" stimulates users' intrinsic motivations and attracts their continuous involvement through gamification. It helps cultivate users' green consumption habits unconsciously and brings environmental benefits indirectly. Using green gamification to promote green consumption is in line with the strategic needs of ecological civilization construction. It also satisfies the industry trend of green consumption market development. Therefore, it is significant to motivate users' green behaviors through gamification.

Let the light shoot into the office. There are three colleagues in one office. One guy didn't know where to put the used carton, so he threw them near the daily garbage can. The other two knew where to put it, but one was lazy to do that, and the other one did that sometimes. Last week, they began to play a green gamification game recommended by their boss. In the beginning, they found the game is funny. However, with the loss of freshness, they wanted to give up. But the coupon given by the platform brought them the free juice, they continued to play the game. Through the social interaction inside the game with other colleagues, they knew more about the news and knowledge about green behaviors. Through the game, their environmental knowledge increase, and all of them try to get used to some daily green behaviors, including the used carton reused behaviors. The boss said they might form the energy-saving at different times, but all of them can achieve the green behavior with the increasing involvement of the game. So, why the green gamification game is so magic? What is the real mechanism? The existing gamification cultivation design mechanics rarely has a gradual process from short-term research to long-term research, and there is little research containing discussion on the topic of green environmental protection behaviors.

This paper distinguishes three features of users (strong environmental attitude with weak environmental knowledge, weak environmental attitude with strong environmental knowledge, environmental attitude equals to environmental knowledge), and discusses the formation of the environmental norm, and the transformation of short-term to long-term goals, called environmental cultivation norm, which is changing with the increasing involvement degree of users in the green gamification platform, as shown in Figure 1. Based on the short-term needs of the hedonic goal and the gain goal, how does gamification affordance affect users' participation in gamification green activities? Based on long-term norm goal, how does continuous user engagement affect their green environmental behaviors? In order to answer the above questions, it is particularly critical to explore effectively designing gamification strategies to motivate users' green behaviors.



Source: This study.

Figure 1: Research framework.

Based on the goal framing, this paper considers three target motivations of user behavior, proposes the formation and cultivation mechanics of green behaviors in the green gamification platform, and builds a model considering the process of users' engagement. First, both short-term utility (satisfy users' hedonic goal, gain goal) and long-term utility (satisfy users' normative goal), gained by users from green gamification platform, are deeply analyzed and depicted; then, according to the established utility model, we mainly concern the decision point, analyze and solve the formation point and the cultivation point; finally, example analysis is given to verify the solution. By comparing three types of users (individual quality of high, medium, and low), this paper concludes that high-quality individuals with strong environmental attitudes and weak environmental knowledge can form and cultivate a habit of green behavior, acquiring a lower involvement degree than the other two kinds of participants. And the above result will not be affected by the contribution ratio of hedonic experience and expectancy-value to short-term value. The result can be used by organizations that are applying gamification designs in a variety of ways to engage and steer employees and consumers toward targeted goals.

### BACKGROUND AND MODEL PREMISE

In goal framing theory, Lindenberg and Steg (2007) point out that individual behaviors are mainly influenced by three motivation goals: hedonic goal, gain goal, and normative goal. Especially, the hedonic goal refers to the individual pursuit of short-term emotional experience (such as hedonic experience), while the gain goal refers to the individual chase of maximum benefit (such as expectancy-value) after weighing costs and benefits in the short term. However, the normative goal refers to individuals' compliance with behaviors they deem appropriate (such as environmental norms). These three goals can also correspond to emotional motivations, interests weighing motivations that are likely to affect individual green behaviors in the short term, ethical and normative motivations formed in the long term (Hsu & Chen, 2018; Sun et al., 2018). Therefore, goal framing theory provides a suitable theoretical perspective for exploring individual green behaviors and motivations.

Gamification is a design concept that incorporates gamification elements into non-game situations (Liu et al., 2017). It can build a whole game in a virtual environment. It is composed of some gamification elements, mechanics, and other gamified technical features (gamification features) (Tobon et al., 2020). To increase the gamefulness and funness of the system, gamification elements, mechanics, and other technical means could be added to the system design. In this way, users' psychological needs can be satisfied, and their participation motivations can be stimulated. (Koivisto & Hamari, 2019). Affordance refers to users' perceptions that technology provides them with the possibility to implement actions, connecting the relationship between gamification features and user psychology (Chen et al., 2019). Gamification affordance is an effective perspective to analyze the intrinsic relationship between gamification features and user psychology, representing the extent to which users perceive that they are likely to use gamification information systems to perform tasks (Suh et al., 2017). Gamification design is centered on meeting users' needs and stimulating their participation motivations. Through the reasonable combination of gamification elements and gamification mechanics, users' psychological needs can be satisfied by gamification features, thereby promoting users' participation in specific tasks (Moro et al., 2019). Furthermore, gamification elements are system components that show game information to users, while gamification mechanics are rules and methods designed for players to interact with gamification information business systems (Featherstone & Habgood, 2019; Liu et al., 2017). Through the reasonable configuration and effective design of gamification elements, mechanics, and other gamification features, different target motivations of users can be stimulated, which promotes their participation in green gamification activities and then stimulates users' green environmental protection behaviors. To design an attractive gamification information system and promote the continuous participation of users, it is necessary to deliver the affordance given by gamification features, namely gamification affordance successfully (Suh et al., 2017). The combination of gamification features of gamification information system and users' subjective feelings will empower users to produce different gamification manifestations or affect users' feeling degree (Koivisto & Hamari, 2019; Suh & Wagner, 2017).

According to the above discussions about gamification and goal framework, a good design of a green gamification platform can enhance users' hedonic experience ( $U_1$ ), as well as their expectancy-value ( $U_2$ ), attracting users to continue engaging in green gamification activities. When users get involved in gamified green activities for a long time, their environmental protection

norms are more likely to transfer from gamified platform to real life ( $U_L$ ), thus guiding users to transform from participating in gamified green activities to green behaviors. By describing the process of users' involvement in green gamification activities, we measure the short-term utility ( $U_S = U_1 + U_2$ ) and long-term utility ( $U_L$ ) of users under the influence of different gamification design strategies are of value. Through solving the balance between short-term utility and long-term utility of users, the optimal gamification design strategy to motivate users' green behaviors can be explored.

The occurrence of most phenomena in real life can be described by Poisson distribution. The changes of users' involvement degree in the process of gamification's rise in rank also show a similar distribution. That means users within a certain level range (such as the middle level) have the highest involvement degree. Users at a low level feel too easy to feel enthusiasm. Conversely, users at high levels have a sense of frustration due to the difficulty of the promotion. Both of these two situations lead to a relatively low involvement degree. Therefore, it is assumed that the user's level promotion is independent and obeys the Poisson distribution with a parameter  $\lambda$ . Then, we have:

$$P(X = k) = \frac{\lambda^k}{k!} e^{-\lambda}, (k = 0, 1, 2, \dots), \quad (1)$$

where  $P(X = k)$  is the probability that the user will be promoted to level  $k$  during the game participation process. The users' degree of involvement  $q$  is directly affected by the promotion probability, we then have  $q = \gamma P(X = k)$ ,  $\gamma > 0$ , where  $\gamma$  indicates a constant coefficient. The user involvement degree is essential to both the short-term and long-term utility of users. It is also the main factor to achieve the balance and transformation of the short-term and the long-term utility of users and to stimulate green behaviors. Other gamification affordance, e.g., rewards (marks, points), visualization of achievement (rank, status), self-presentation (medals, trophies), competition (leaderboards, challenges), interaction (social bond), are also subject to Poisson distribution. Here, we focus on the short-term utility and long-term utility of strategy design based on the middle-level promotion mechanism of visualization of achievement.

## ANALYZE AND DEPICT THE SHORT-TERM UTILITY AND LONG-TERM UTILITY

### The Utility Combination Representation of Hedonic Experiences in Short-Term Goals

The hedonic goal is one of the main motivations affecting users' involvement in gamified green activities in the short term. According to the results from previous literature (Koivisto & Hamari, 2019; Werbach & Hunter, 2012), the user's hedonic goal in the gamification context can be divided into three types of hedonic experiences: challenge enjoyment, experimental enjoyment, and social enjoyment. Among them, challenge enjoyment refers to the playfulness that users experience when they successfully respond to challenges or solve problems in the process of involvement in gamified green activities. Experimental enjoyment refers to the freshness experienced by users during their involvement in gamification. Social enjoyment refers to the pleasure derived from users' involvement in gamification by making social bonds with others. Flow is a user's emotion about an activity or a thing. Flow theory believes that when a person is immersed in a certain activity, there is a temporary loss of self-awareness of himself or herself. He or she will think that time passes faster and will perceive challenge of the activity matches his or her skills (Berger, Schlager, Sprout, & Herrmann, 2017). In the context of gamified green e-commerce, users' experience of the sense of entertainment, freshness, and social bonds through gamified interactive activities will stimulate users' hedonic-goal motivation, promote their immersion in gamification information system and generate flow. In this way, users' willingness to participate in gamified green activities and the degree of involvement can be improved (such as extending users' immersion time, raising users' daily liveness, improving game proficiency, etc.). Therefore, the following model assumptions about the combination of hedonic experience utility in short-term goals need to be considered:

- According to the hypotheses, user involvement is  $q$ . There is a positive correlation between the sense of entertainment in the hedonic goal and the degree of user involvement. We then have  $P(q) = pq + \theta_1$ , where  $p > 0$  is the entertainment coefficient. When the engagement scale  $\theta_1$  equals to 0, the sense of entertainment is not evaluated.
- The novelty of the hedonic goal is inverse, which can be represented as  $F(q) = \frac{f}{q}$ , where  $f > 0$  is the freshness coefficient.
- Social enjoyment in the hedonic goal is positively correlated with user involvement. Then we have  $L(q) = sq$ , where  $s > 0$  is the social enjoyment coefficient.

To sum up, the users' hedonic goal is a utility function ( $U_1$ ) of users' involvement in gamified green activities. Therefore, in the short term, the utility function of the hedonic goal can be represented as

$$\begin{aligned} \max U_1(q) &= P(q) + F(q) + L(q) \\ \text{s.t. } q &> 0 \end{aligned} \quad (2)$$

### The Utility Combination Representation of Expectancy-Value in Short-Term Goals

The gain goal is one of the main psychological motivations affecting users' involvement in green gamification activities in the short term. Under the gain goal orientation, many individuals pay more attention to the change of their resource quantity or resource efficiency. Besides, users are very sensitive to the information of value brought by their behaviors (Lindenberg & Steg, 2007). Prospect theory points out that the expectancy-value brought by behavioral tasks will affect users' perception of resources and revenue, which is an important factor to affect individual behaviors (Chipulu, Marshall, Ojiako, & Mota, 2015). Based on prospect theory (Trautwein et al., 2012), the users' gain goal in the context of gamification include four expectancy values: attainment value, utility value, intrinsic value, and cost. Especially, attainment value refers to the value of one person's sense of

accomplishment after completing the behaviors, such as the sense of accomplishment obtained by comparing the rankings with other users. Utility value refers to the external value that an individual expected behaviors such as raffles, coupons, and consumption bonuses after online payment might bring benefits. Intrinsic value refers to the subjective value that can satisfy one's intrinsic needs, e.g., the voluntary tree-planting certificate issued by Ant Forest can satisfy one's psychological need to display one's individuality. Although these values cannot directly meet individual needs, they can be transformed internally to make it. On the contrary, cost refers to the cost generated by individual behaviors (the time and energy paid by participating in gamified green activities), which belongs to a negative value (Sun et al., 2018). It can be seen that the more value enhancement for a player in the context of green e-commerce, the more willingness to get involvement will be generated by users. The involvement degree will also increase at the same time. Therefore, the following model assumptions about the combination of expectancy-value and utility in the short-term goals are proposed:

- According to Wigfield et al. (1996) and Trautwein et al. (2012), based on expectancy-value theory, let  $\alpha$  be the attainment value coefficient;  $u$  be the utilization value coefficient; denote  $i$  as the intrinsic value coefficient. Considering the expected income coefficient  $v > 0$ , the comprehensive expectancy-value coefficient is formulated as  $v = \alpha + u + i$ , where  $\alpha, u, i > 0$ .
- The attainment value, utility value, and intrinsic value contained in the expectancy-value of the gain goal are positively correlated with the user involvement degree (Trautwein et al., 2012). Therefore, let  $V(q) = vq + \theta_3 = (\alpha + u + i)q + \theta_3$  be the value function. When the degree of involvement equals to 0, the expectancy value is not evaluated, so  $\theta_3 = 0$ .
- According to Eccles, Wigfield (2002), and Trautwein et al. (2012), the cost of individual behaviors is a negative value. It has a U-shaped relationship with user involvement. Specifically, there is a certain effort required for users to participate in the early stage and to keep learning about the game. As the degree of involvement deepens, users are likely to closely consider the opportunity cost of each of their decisions and feel performance anxiety for fear of failure after they reach a certain height. So, there is an appropriate level of engagement along with the lowest overall cost to the user. Then the function equation between cost and the degree of involvement can be represented as  $C(q) = a_2q^2 + b_2q + c_2$ , where  $a_2, c_2 > 0, b_2 < 0, \frac{4a_2c_2 - b_2^2}{4a_2} > 0$ .

To sum up, the users' gain goal is the utility function ( $U_2$ ) of user's involvement degree  $q$  in green gamification activities. So, the utility function of the gain goal in the short term is defined as:

$$\begin{aligned} \max U_2(q) &= V(q) + C(q) \\ \text{s. t. } &q > 0 \end{aligned} \quad (3)$$

Users' short-term utility  $U_s$  includes the pursuit of the hedonic goal and the gain goal. Short-term utility  $U_s$  consists of hedonic utility  $U_1$ , and gain utility  $U_2$ . Based on flow theory, "hedonic utility"  $U_1$  is composed of users' hedonic experience of entertainment, freshness, and social bonds. Based on the prospect theory, "gain utility"  $U_2$  consists of expectancy-value factors: attainment value, utility value, intrinsic value, and cost. So, the short-term utility function  $U_s$  is:

$$U_s(q) = \alpha_1 U_1(q) + \alpha_2 U_2(q), \quad \alpha_1, \alpha_2 \in [0,1] \quad (4)$$

The short-term utility function  $U_s$  derived from the above is:

$$\begin{aligned} \max U_s(q) &= \alpha_1 U_1(q) + \alpha_2 U_2(q) \\ \text{s. t. } &q > 0 \end{aligned} \quad (5)$$

### The Utility Portfolio Representation of a Specification in Long-Term Goal

The normative goal is the main psychological motivation that affects users' green behaviors in the long term. The normative goal refers to the constraints of cognition and attitude on individual behaviors, which must be met in the process of individual behaviors implementation (Wittenberg, Blöbaum, & Matthies, 2018). Based on the results of current literature (Kibourne & Pickett, 2008; Wittenberg et al., 2018), users' perception of the normative goal of personal behaviors will be influenced by environmental norms (Norm). Therefore, the environmental norms of environmental knowledge and environmental attitude are taken as the measurement of the normative goal. Among them, environmental knowledge indicates the user's knowledge and understanding of environmental knowledge. Environmental attitude refers to the user's subjective attitude towards environmental behavior (Steinhorst & Klöckner, 2017). The normative goal can influence the users' inner demand for green behaviors for a long time and restrain behaviors at the same time. The study found those users with higher environmental norms are more inclined to make altruistic green behaviors than the users with lower environmental norms. Thus, the former one is more likely to engage in green behaviors (Steinhorst & Klöckner, 2017). The normative goal mainly affects the green behaviors of users from the aspect of social norms. Previous literature shows that the stronger an individual environmental norm is, the more likely he or she is to engage in green behaviors that benefit the interindividual (Günther, Kacperski, & Krems, 2020; Kibourne & Pickett, 2008).

Construct the cognitive dissonance coefficient  $B = \frac{k}{g} - 1 \in [-1,1]$ , where  $k > 0$  indicates the coefficient of environmental knowledge,  $g > 0$  represents the coefficient of environmental attitude.

- According to cognitive dissonance theory, when users are continuously involved in gamified green activities and complete a series of gamification tasks related to environmental protection, new environmental knowledge and attitude will be

generated in the game. However, when users return to reality, the new cognition and attitude of environmental protection may be inconsistent with the original cognition and attitude. To eliminate such dissonance, users will change the old cognition and attitude of environmental protection to obtain psychological balance. At this point, there are the following three cases:

- (1) When environmental knowledge is consistent with environmental attitude, then we have  $k = g$ . That means there is no cognitive dissonance, so the cognitive dissonance coefficient is about 0,  $B = 0$ .
  - (2) When environmental knowledge is far less than environmental attitudes,  $k < g$  is held, which shows that users belong to a high-quality group, their environmental attitudes are higher, now  $-1 < B < 0$ .
  - (3) When environmental knowledge is far greater than environmental attitudes,  $k > g$ , It shows that the environmental knowledge provided by gamification can hardly change users' environmental attitudes, now  $0 < B < 1$ .
- Users' original environmental knowledge and attitude will gradually be changed by continuous involvement in long-term self-adaptation in the gamification process. This helps to form the environmental protection norms that are conducive to the common interests of individuals and gradually deepen. In the long-term process, assuming that the involvement degree  $q > 1$ , the normative utility target in the long-term will show exponential growth as the involvement degree deepens:  $U_L(q) = e^{[q-B]}$ . Given that different users' environmental knowledge and attitudes show different relationships when discussing different cases of cognitive dissonance coefficient "  $B$  ", there will be the following situations:
    - (1) When the cognitive dissonance coefficient  $B = 0$ ,  $U_L(q) = e^q$ . That means the normative utility shows normal growth.
    - (2) When the cognitive dissonance coefficient  $B \in [-1, 0]$ , At the same level of involvement, this user's long-term utility  $U_L(q)$  increases most rapidly.
    - (3) When the cognitive dissonance coefficient  $B \in [0, 1]$ , At the same level of involvement, this user's long-term utility  $U_L(q)$  increases relatively slow.

To sum up, the user's long-term normative goal  $U_L$  is the utility function of the user's involvement degree  $q$  in green gamification activities. In the long term, the utility function of the normative goal is defined as:

$$U_L(q) = e^{[q-B]} = e^{[q-(\frac{k}{g}-1)]} \quad (6)$$

s. t.  $q > 1$

#### THE ANALYSIS OF UTILITY MODEL AND OPTIMAL DECISION POINT SOLUTION

In short-term goals, the utility function of involvement degree is as follows:

$$U_s(q) = \alpha_1[(pq + \theta_1) + \frac{f}{q} + sq] + \alpha_2[vq + \theta_3 + a_2q^2 + b_2q + c_2] \quad (7)$$

s. t.  $q > 0$

In the long-term goal, the utility function of involvement degree is as follows:

$$U_L(q) = e^{[q-B]} = e^{[q-(\frac{k}{g}-1)]} \quad (8)$$

s. t.  $q > 1$

#### The Formation Point of Environmental Protection Norms

With the increase of users' involvement, both short-term utility and long-term utility of users rise according to their respective function rules, as shown in (7) and (8). When two utility functions grow at the same rate, that is,

$$\frac{\partial U_s}{\partial q} = \frac{\partial U_L}{\partial q} \quad (9)$$

At this point, the derivative of the short-term utility to the involvement degree is equal to the long-term utility, and the equilibrium of short-term utility and long-term utility growth is achieved. This point can be regarded as the goal attainment point of the norm. Based on the involvement degree of this point, the environmental protection attitude of users can be changed to form the environmental protection norm. After this point, the growth rate of the long-term normative utility of users is significantly higher than that of the short-term utility, and the main motivation of users' green gamification activities begins to shift from hedonic experience and expectancy-value to target norm, which generates the possibility of users' green behaviors.

To find the solution of the formation point of environmental protection norms, first of all, from the above,

$$\frac{\partial U_s}{\partial q} = \alpha_1 p - \frac{\alpha_1 f}{q^2} + \alpha_1 s + \alpha_2 (v + 2a_2 + b_2)$$

$$\frac{\partial U_L}{\partial q} = e^{q-(\frac{k}{g}-1)}$$

Then,

$$\alpha_1 p - \frac{\alpha_1 f}{q^2} + \alpha_1 s + \alpha_2(v + 2a_2 + b_2) = e^{q - (\frac{k}{g} - 1)}$$

Transform the above formula,

$$e^{q - (\frac{k}{g} - 1)} + \frac{\alpha_1 f}{q^2} = \alpha_1 p + \alpha_1 s + \alpha_2(v + 2a_2 + b_2)$$

The left-hand side of the equation contains the unknown element  $q$ , and the right-hand side is a constant. Let  $K = \alpha_1 p + \alpha_1 s + \alpha_2(v + 2a_2 + b_2)$ , then the equation becomes:  $e^{q - (\frac{k}{g} - 1)} + \frac{\alpha_1 f}{q^2} - K = 0$ . We can let  $f(q) = e^{q - (\frac{k}{g} - 1)} + \frac{\alpha_1 f}{q^2} - K$ . Then we can find,

$$f'(q) = e^{q - (\frac{k}{g} - 1)} - \frac{2\alpha_1 f}{q^3}$$

It can be seen that  $f(q)$  decreases firstly and then increases, the inflection point is  $x$ , and  $x$  is the solution of  $q^3 e^q = 2\alpha_1 f e^{(\frac{k}{g} - 1)}$  (transform from the above formula).

And then, we know that the minimum value of  $f(q)$  is  $f(x)$ . At this point, the following three cases need to be discussed:

- 1,  $f(x) = 0$ , think about  $\frac{\partial U_s}{\partial q} = \frac{\partial U_L}{\partial q}$  there has one point that  $x$  can be held.
- 2,  $f(x) < 0$ , think about  $\frac{\partial U_s}{\partial q} = \frac{\partial U_L}{\partial q}$ , there are two points that one is over  $x$ , and the other belongs to the range  $[0, x]$  are held.
- 3,  $f(x) > 0$ , then  $\frac{\partial U_s}{\partial q} = \frac{\partial U_L}{\partial q}$  has no point, that is,  $\frac{\partial U_L}{\partial q} > \frac{\partial U_s}{\partial q}$  establishes constantly. At this point, there is no formation point of environmental protection norms.

### The Transition Point of Environmental Protection Norms

After the formation of the environmental protection norms, although users begin to break away from the dominance of short-term enjoyment and profit motivations, it is difficult to motivate users' green behaviors because the long-term utility of users is lower than the short-term utility. With the further deepening of user involvement, when the long-term utility growth of users is consistent with the short-term utility, namely:

$$U_s = U_L \quad (10)$$

It can be regarded as the transition point between the user's short-term goals and the user's long-term goals. After this point, long-term utility surpasses short-term utility, and users no longer need to stimulate enjoyment and gains through gamified green activities but spontaneously carry out green behaviors due to the cultivation of environmental protection norms.

By solving the above two key points, we can calculate one certain involvement degree, which can be calculated. In this involvement degree, users happen to reach the environmental protection norms and form the green behaviors. According to the distribution law of involvement degree at this moment, the optimal gamification grade design strategy that encourages users to continue to participate and carry out green behaviors can be determined. We can find,

$$\alpha_1 \left( (pq + \theta_1) + \frac{f}{q} + sq \right) + \alpha_2(vq + \theta_3 + a_2 q^2 + b_2 q + c_2) = e^{q - (\frac{k}{g} - 1)}$$

Transform the above formula,

$$\alpha_1 pq + \frac{\alpha_1 f}{q} + \alpha_1 sq + \alpha_2 vq + \alpha_2 a_2 q^2 + \alpha_2 b_2 q - e^{q - (\frac{k}{g} - 1)} = -\alpha_1 \theta_1 - \alpha_2 \theta_3 - \alpha_2 c_2$$

Among them, let  $P = -\alpha_1 \theta_1 - \alpha_2 \theta_3 - \alpha_2 c_2$  can be regarded as a constant.

Therefore, let

$$g(q) = \alpha_1 pq + \frac{\alpha_1 f}{q} + \alpha_1 sq + \alpha_2 vq + \alpha_2 a_2 q^2 + \alpha_2 b_2 q - e^{q - (\frac{k}{g} - 1)},$$

we can find,

$$g'(q) = 2\alpha_2 a_2 q + \alpha_1 p + \alpha_1 s + \alpha_2 v + \alpha_2 b_2 - e^{q - (\frac{k}{g} - 1)} - \frac{\alpha_1 f}{q^2}$$

$$g''(q) = 2\alpha_2 a_2 + \frac{2\alpha_1 f}{q^3} - e^{q - (\frac{k}{g} - 1)}$$

Let  $g''(q) > 0$ , then  $q < X_1$ ,  $X_1$  is the solution that  $g''(q) = 0$ , and the solution can be obtained by binary search. Therefore, we know that  $g'(q)$  is increasing at  $[0, X_1]$ , and decreasing at  $[X_1, +\infty]$ . In it,  $\max g'(q) = g'(X_1)$ . There are two cases that need to be discussed,

1,  $g'(X_1) < 0$ , which means  $g(q)$  is decreasing at  $[0, +\infty]$ . When  $g(0) > 0$ , there is a zero point in it, and the solution can be obtained by binary search.

2,  $g'(X_1) > 0$ , then we let  $X_2 \in [0, X_1]$ , and  $X_3 \in [X_1, +\infty]$ . The solution can be obtained by binary search through letting  $g'(q) = 0$ . So, we can know  $g(q)$  is decreasing at  $[0, X_2]$ , increasing at  $[X_2, X_3]$ , and decreasing at  $[X_3, +\infty]$ . In this case, there are several situations that need to be discussed:

2.1, When  $g(X_2) > 0$ , there is a point that satisfies  $U_s = U_L$ , which locates at  $[X_3, +\infty]$  and can be obtained by binary search.

2.2 When  $g(X_2) = 0$ , there are two points that satisfy  $U_s = U_L$ , the one of which is  $X_2$ , and the other located at  $[X_3, +\infty]$  and can be obtained by binary search.

2.3 When  $g(X_2) < 0$  and  $g(X_3) > 0$ , there are three points that satisfy  $U_s = U_L$ , which are respectively located at  $[0, X_2]$ ,  $[X_2, X_3]$ ,  $[X_3, +\infty]$ .

2.4 When  $g(X_3) = 0$ , there are two points that satisfy  $U_s = U_L$ , the one of which is  $X_3$ , and the other located at  $[0, X_2]$ .

2.5 When  $g(X_3) < 0$  and  $g(0) > 0$ , there is a point that satisfies  $U_s = U_L$ , which locates at  $[0, X_2]$ .

2.6 When  $g(0) = 0$ , there is a point that satisfies  $U_s = U_L$ , which is the zero point.

2.7 When  $g(0) < 0$ , there is no point that satisfies the equation.

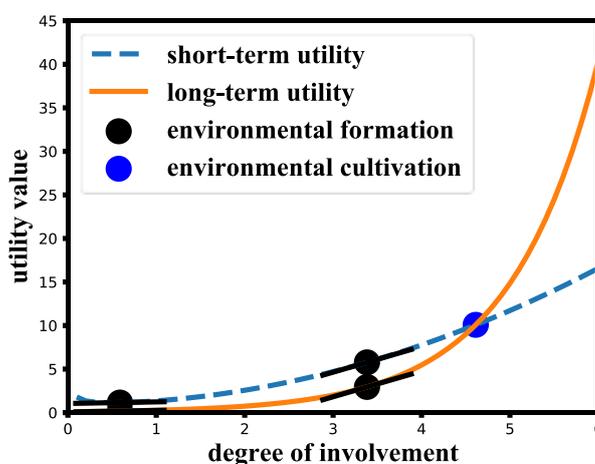
### EXAMPLE ANALYSIS

When the corresponding parameters are set as shown in Table 1, the process of the formation and the cultivation of the user's environmental protection norm can be seen in Figure 2, showing that the formation of the environmental protection point is generated at  $[0,1]$  and  $[3,4]$ . Since we definite that calculated should meet  $q > 1$ , which is a prerequisite for long-term utility function discussion. Therefore, the degree of involvement at  $[3,4]$  is focused. With the increase of involvement, users gradually meet the environmental norm formation point. Before the environmental regulations are formed, the growth rate of the short-term utility of users is higher than that of long-term utility ( $\frac{\partial U_s}{\partial q} > \frac{\partial U_L}{\partial q}$ ); after the formation of environmental protection norm, although the short-term utility of the early users is still higher than the long-term utility of the users ( $U_s > U_L$ ), because the long-term utility is growing faster than the short-term utility ( $\frac{\partial U_s}{\partial q} < \frac{\partial U_L}{\partial q}$ ), users gradually develop environmental norms. At this point, when the short-term utility function intersects the long-term utility function, the user realizes the cultivation of environmental protection standards ( $U_s = U_L$ ). After that, the user's long-term utility rises exponentially, that is, much higher than his short-term utility ( $U_s < U_L$ ), which is consistent with our initial hypotheses.

Table 1: Preliminary parameter settings 1.

parameter	$\alpha 1$	$\alpha 2$	$p$	$f$	$s$	$v$	$K/g$	$q$	$\theta 1$	$\theta 3$	$a 2$	$b 2$	$c 2$
value	0.1	0.9	0.9	0.9	0.9	0.7	1	0.1	0	0	0.5	-1	1

Source: This study.



Source: This study.

Figure 2: Short-term and long-term utility diagram in the process of users' increasing involvement.

### The Formation of Environmental Protection Norms

Suppose there are three types of users ( $B = 0, -1 < B < 0, 0 < B < 1, B = \frac{k}{g} - 1 \in [-1, 1]$ ). They correspond to environmental knowledge that is consistent with environmental attitude ( $k = g$ ), environmental knowledge that is far less than environmental attitude ( $k < g$ ), and environmental knowledge is far more than environmental attitude ( $k > g$ ). The detailed discussion on the formation and development of environmental protection norms for the three types of users is as follows. The parameter settings of the three user types are shown in Table 2.

Table 2: Parameter settings for three types of users 2.

Type	High-quality individuals	General public individuals	Low-quality individuals
Definition	Environmental knowledge is far less than environmental attitude ( $k < g$ )	Environmental knowledge is consistent with environmental attitude ( $k = g$ )	Environmental knowledge is far more than environmental attitude ( $k > g$ )
Value	$K = 0.5g$	$K = g$	$K = 2g$

Source: This study.

Figure 3 shows the changing trend of involvement  $q$  corresponding to the formation point of environmental protection norms, as the freshness  $f$  changes when the parameters  $\alpha_1$  and  $\alpha_2$  are set. Taking Figure 3-a as an example, in the case of involvement  $q > 1$ , the user type is  $K = 2g$ . Participants who have environmental knowledge are stronger than environmental attitude when compared with users with lower environmental knowledge than environmental attitude ( $K = 0.5g$ ), higher involvement is required to realize the formation of environmental norms. Meanwhile, for users with environmental knowledge equal to environmental attitude ( $K = g$ ), the level of engagement required to shape environmental norms falls somewhere in between. Different  $\alpha_1$  and  $\alpha_2$  represent the proportions of hedonic experience and expectancy-value in the short-term utility function. As can be seen from the following example figure, when discussing freshness  $f$  under different values of  $\alpha_1$  and  $\alpha_2$ , the high-quality group has a lower involvement degree than other types of users in realizing the formation of environmental protection norms. According to the figure, it can be preliminarily concluded that  $\alpha_1$  and  $\alpha_2$  do not affect the relative value of the involvement degree of three types of users in the formation of environmental protection norms.

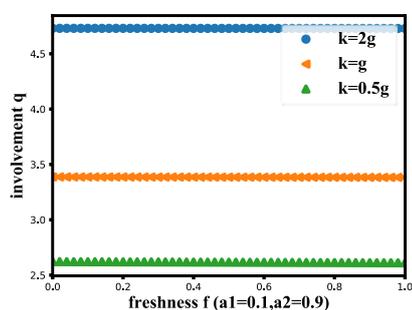


Figure 3-a

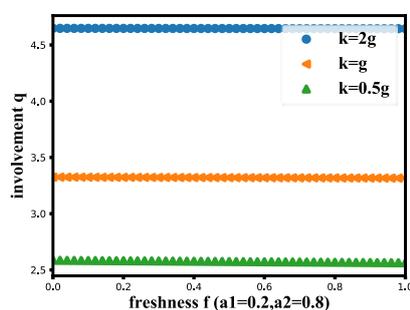


Figure 3-b

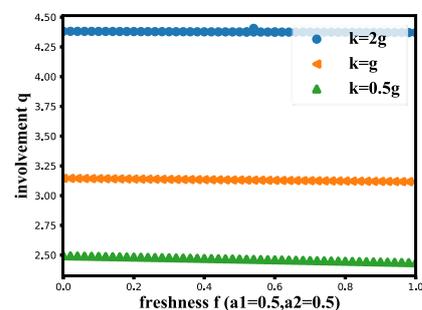


Figure 3-c

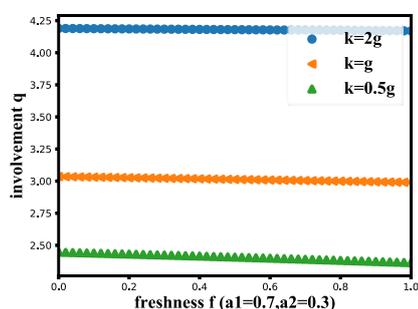


Figure 3-d

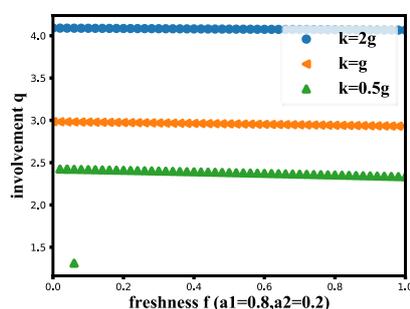


Figure 3-e

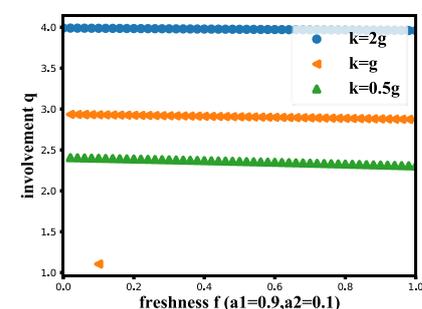


Figure 3-f

Source: This study.

Figure 3: The changing trend of goal formation points with involvement  $q$  in the changing process of freshness  $f$ .

Control other parameters. When discussing a specific parameter (such as entertainment  $p$ ), further set parameters based on Table 1, as shown in Table 3. By observing the results of the variation of different parameters—the variation trend of the formation points of environmental protection norms and the relative situation of three types of users, it can be seen that when the high-quality group, the general public group, and the low-quality group realize the formation of environmental protection norms, their requirements for involvement degree increase successively.

Table 3: Preliminary parameter settings 2.

	$\alpha 1$	$\alpha 2$
entertainment $p$	0.9	0.1
freshness $f$	0.1	0.9
social enjoyment $s$	0.5	0.5
value $v$	0.1	0.9
cost $c$	0.5	0.5

Source: This study.

Figure 4-b, and Figure 4-d respectively represent the situation when the concerned parameters are freshness  $f$  and cost  $c$ . As it can be seen from the figure, when the parameter values are shown in Table 3, the involvement degree of three types of users in forming environmental protection norms will not change significantly with the increase of freshness  $f$  or cost  $c$ . Figure 4-c and Figure 4-e represent the situation when the concerned parameters are social enjoyment coefficient  $s$  and value  $v$  respectively. It can be seen from the figure that when the parameter values are shown in Table 3, three types of users form environmental protection norms. The corresponding involvement requirements increase with the raising of social enjoyment  $s$  or value  $v$ . To sum up, when the values of relevant parameters are shown in Table 3, in the process of participating in green environmental protection games, the degree of freshness in the enjoyment experience brought by games and the fluctuation of utility cost in the expectancy-value have almost no interference on the formation point of environmental protection norms. However, the change of social enjoyment in hedonic experience or value in expectancy-value will affect the formation of three types of user environmental protection norms. That is, there is a corresponding change trend in the requirements of involvement degree. Correspondingly, Figure 4-a represents the situation when the attention parameter is entertainment  $p$ . In particular, there are two key points for users to achieve environmentally normative behaviors. Focuses on the situation with high involvement degree (as shown in the figure,  $p = 1.5$ ), which is similar to the changing trend of social enjoyment  $s$ .

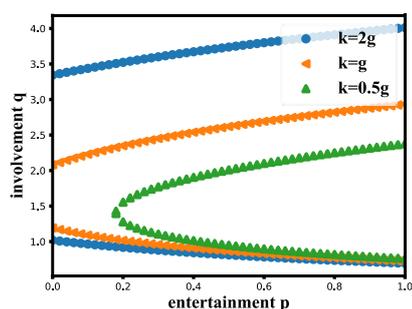


Figure 4-a

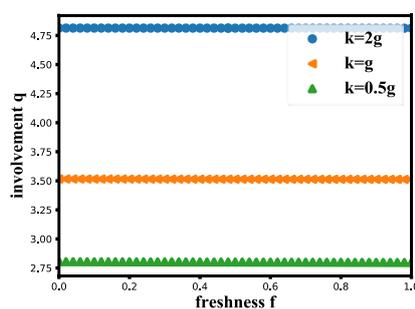


Figure 4-b

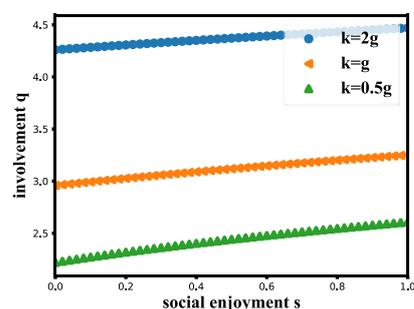


Figure 4-c

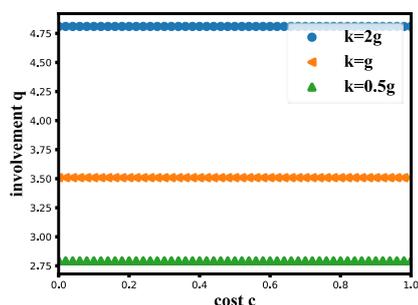


Figure 4-d

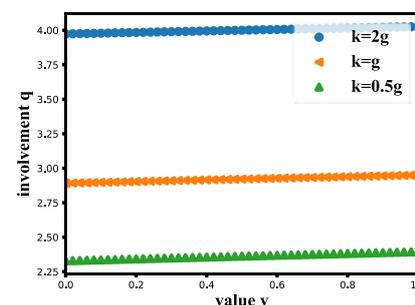


Figure 4-e

Source: This study.

Figure 4: Environmental norm formation points.

To sum up, when it comes to three kinds of users, it can be seen that when the high-quality group, the general public group, and the low-quality group realize the formation of environmental protection norms, their requirements for involvement degree increase successively. Furthermore,  $\alpha 1$  and  $\alpha 2$  do not affect the relatively required involvement degree of three types of users in the formation of environmental protection norms when focusing on one parameter. When discussing a certain parameter, the change of values of  $\alpha 1$  and  $\alpha 2$  will mainly affect the change of the specific involvement degree required by the formation of environmental protection norms while this effect is less than the effect of the type of users itself.

### The Cultivation of Environmental Protection Norms

In the study of environmental protection norm cultivation, when discussing a specific parameter (such as entertainment  $p$ ), similarly, the parameter setting is further adjusted based on Table 1, as shown in Table 4. It is similar to the formation point of environmental protection norms. By observing the results of the changes of different parameters—the changing trend of the cultivation point of environmental protection norms and the relative situation of three types of users, it can be seen that when high-quality people, ordinary people, and low-quality people realize the cultivation point of environmental protection norms, their requirements for involvement degree also increase successively.

Table 4: Preliminary parameter settings 4.

	$\alpha 1$	$\alpha 2$
entertainment $p$	0.9	0.1
freshness $f$	0.1	0.9
social enjoyment $s$	0.5	0.5
value $v$	0.1	0.9
cost $c$	0.5	0.5

Source: This study.

Based on parameter setting in Table 4, by observing Figure 4-b, that is, mainly pay attention to the freshness  $f$ . At this point, the involvement degree of the three types of users in the realization of environmental protection norms will not change greatly with the increase of the freshness  $f$ . It means that in the process of participating in green environmental protection games, the increase and decrease of the freshness  $f$  in the process of the game will almost not interfere with the cultivation point of environmental protection norms, that is, there is no evident change in the requirements for the involvement degree.

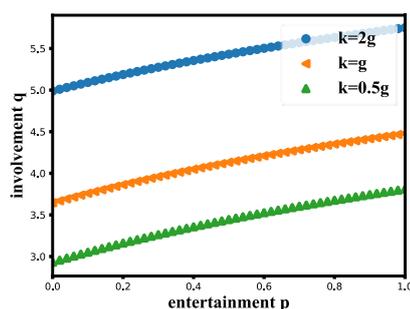


Figure 5-a

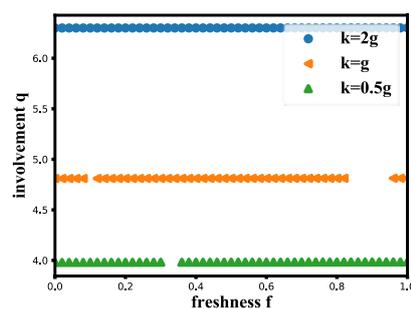


Figure 5-b

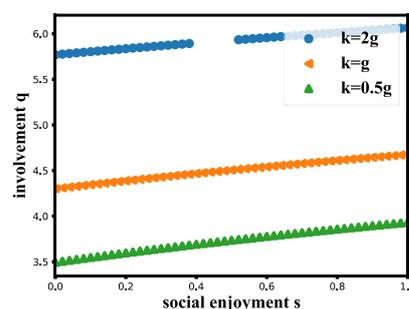


Figure 5-c

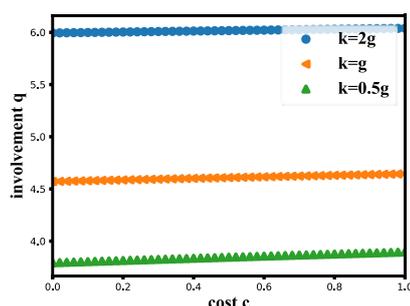


Figure 5-d

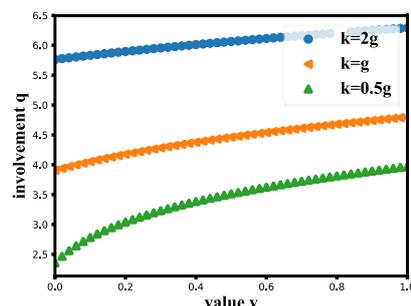


Figure 5-e

Source: This study.

Figure 5: Environmental norm cultivation points.

Figure 4-a, Figure 4-c, Figure 4-d, and Figure 4-e respectively represent the situation when the parameters are entertainment  $p$ , social enjoyment  $s$ , cost  $c$ , and value  $v$ . It can be seen from the figure that the parameters are set, as shown in Table 4. When three types of users are discussed to develop environmental protection norms, the requirements for the corresponding involvement degree will raise with the increase of each parameter when reaching the critical point of developing environmental protection norms. In addition, with the increase of cost  $c$ , social enjoyment  $s$ , and entertainment  $p$ , the involvement degree required to realize the cultivation point of environmental protection norms is gradually increased. It can be concluded that the changes of entertainment  $p$ , social enjoyment  $s$ , cost  $c$ , and value  $v$  will affect the cultivation of three types of user environmental protection norms. That is, there is a corresponding trend of changes in the requirements for the involvement degree. In particular,

Figure 4-e represents the situation where we focus on value  $v$ . When  $v < 0.2$ , the change of value in the process of the development of environmental protection norms has a stronger impact on the requirements of involvement.

To sum up, when it comes to three kinds of users, it can be seen that while the high-quality group, the general public group, and the low-quality group realize the cultivation of environmental protection norms, their requirements for involvement degree go up successively. Furthermore,  $\alpha_1$  and  $\alpha_2$  do not affect the relative involvement degree of the three types of users in the development of environmental protection norms when focusing on one parameter. When discussing a certain parameter, the change of values of  $\alpha_1$  and  $\alpha_2$  will mainly affect the change of the specific involvement degree required by the cultivation of environmental protection norms, while this effect is less than the effect of the types of the users itself.

In summary, the following conclusions can be drawn:

- (1) When the high-quality crowd, the general public crowd, and the low-quality crowd realize the formation and cultivation of environmental protection norms, their requirements for involvement degree all increase sequential. It means the high-quality crowd in their early involvement can form and develop environmental protection norms. This result is not affected by the contribution proportion of hedonic experience and expectancy-value to the short-term utility function.
- (2) Considering the influences of the changes of entertainment  $p$ , social enjoyment  $s$ , value  $v$ , freshness  $f$ , and cost  $c$  on the formation and cultivation of environmental protection norms by users in the short-term expected goals, it can be known that: The different proportions of hedonic experience and expectancy-value experienced by users in short-term goals of the game process will affect the formation of environmental protection norms, and influence the level of users involvement required by the cultivation of environmental protection norms, but this effect is weaker than that of the types of users.

### CONCLUSION

Existing research of gamification cultivation mechanics rarely has a gradual process from short-term research to long-term, and there is little research containing discussion on the topic of green environmental protection behaviors. Based on the goal framing, this paper considers three target motivations of user behavior, proposes the formation and cultivation mechanics of green behaviors in the green gamification platform, and builds a model considering the process of users' engagement. According to goal framing theory, this paper focuses on the green gamification platform in order to contribute to individual green behaviors, then provides ideas for potential strategies in the ways of effectively designing gamification, especially discusses the formation and cultivation point considering the short-term utility and long-term utility at the same time. Contributions of this research are as follows.

Theoretically, this paper deduces the process of how gamification affordance effects users' involvement in green gamification activities in the short term of the hedonic goal and the gain goal. Besides, this paper answers the questions of how continuous user engagement affects their green environmental behaviors on long-term norm goals. Specially, we infer the formation and cultivation of the users' green behaviors in view of the short-term utility (satisfy users' hedonic goal, gain goal) and long-term utility (satisfy users' normative goal). Last but not least, we broaden the gamification platform design in the way of the goal framework utility.

Practically, this paper finds out that when the high-quality individual, the general public individual, and the low-quality individual realize the formation and cultivation of environmental protection norms, their requirements for involvement degree all increase sequential, which can be used by the organizations who are applying gamification designs in a variety of ways to engage and steer employees and consumers toward targeted goals. Here, we focus on green behaviors' formation and cultivation. The potential design gamification strategies can motivate users' green behaviors effectively.

Some limitations also are in this paper. First of all, this paper focuses on the short-term utility and long-term utility of strategy design based on the middle-level promotion mechanism of visualization of achievement. However, another gamification affordance such as self-presentation (medals, trophies), competition (leaderboards, challenges) is also subject to Poisson distribution, all of which can also be discussed in the future. Furthermore, based on our results, we hope that our study could be extended by exploring the mix match of different parameters and deducing the reason why it could be, comparing the results, and finding other better-optimized solutions for different situations. Besides, the uses' cultivation habits may decrease as time goes by. Other mechanisms should be discussed in the next step in the future, which help to build a long-term formation in another special situation.

### ACKNOWLEDGMENT

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## An Empirical Analysis of Consumer Impulse Purchases

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### ABSTRACT

In China, shopping festivals such as T-mall Double Eleven, Double Twelve, and JD 618 are the best times for merchants to sell their products. In this paper, to help sellers in shopping festivals, we do an empirical study to identify the main factors that stimulate consumers to make impulsive purchases. Our research results show: (1) logistics services, product praise rate, and product sales volume indirectly affect impulse buying through perceived value as an intermediary; (2) source reliability, pre-sales service, and after-sales service indirectly affect impulse purchase through perceived risk as an intermediary; and (3) commodity prices and product discounts directly affect impulse purchase.

*Keywords:* Behavioural model, e-commerce impulse purchase, transaction utility.

### INTRODUCTION

Nowadays, the rapid growth of Internet penetration and the rise of e-commerce have made online shopping one of the mainstream consumption methods worldwide. In particular, according to the 48th Statistical Report on Internet Development in China in June 2021, the size of China's Internet users reached 1.011 billion, the Internet penetration rate reached 71.6%, and the size of online shopping users reached 812 million, accounting for 80.3% of Internet users. On the double 11, 2021, the single-day turnover of T-mall exceeded RMB 540.3 billion, setting another record high. Furthermore, in the 2021 618 Mid-Year Shopping Festival, Jingdong's cumulative order volume reached a record high of RMB 305.6 billion.

Consumers buy goods in online festivals because buying brings a bigger utility than not buying. However, almost everyone shops impulsively in these shopping festivals characterized by discounted sales. More notably, for consumers who seek more shopping value than practical value, it is unnecessary to have a significant discount to stimulate impulse buying behavior. Thus, studying what factors impact the customers' impulsive purchases in these online shopping festivals is necessary. The study can help merchants correctly understand consumers' psychological activities during online shopping and formulate reasonable marketing strategies, rather than just making discounts. On the other hand, the study may tell consumers which aspects of product information are worthy of their attention to reducing perceived risks and the uncertainty of online shopping.

To this end, in this paper, we first empirically analyze the hypothetical factors that stimulate impulse purchases in online shopping festivals, focusing on young shoppers (the main driving force behind online shopping). Then, we develop a theoretical framework of the factors that influence consumers' desire to shop and validate the model with a questionnaire survey of the study participants. Finally, we discuss how merchants can use our findings to develop marketing strategies to maximize their utility in the face of different consumer needs. This paper considers consumer needs in two types: (1) the need to obtain the utility value of goods and (2) the need to obtain the shopping value of goods.

The remainder of this paper is structured as follows. Section 2 discusses the hypotheses and model of impulse buying behavior of young online shoppers in the context of shopping festivals. Section 3 presents the questionnaire and statistically analyses the data collected from the questionnaire to verify our hypotheses and model. Section 4 discusses how the sellers can use the results of our empirical analysis in practice. Section 5 compares our work with related work. Finally, Section 6 concludes this paper with future work.

### HYPOTHESES AND RESEARCH MODELS

The section will discuss the hypotheses and model of impulse buying behavior of young online shoppers in the context of shopping festivals.

#### Theoretical Hypothesis

In commodity trading, logistics can be considered an ancillary service product for purchasing commodities, and its essence is to meet customer needs within the time required by customers. Logistics services have multiple dimensions, including delivery time, transportation costs, cargo damage rate, delivery reliability, returns and exchanges, and attitudes of service personnel (Rajendran et al. 2018). On the Taobao shopping platform, consumers' online evaluations of purchased goods mainly include three scoring items: description matching, logistics services, and service attitudes, which indicate that logistics services have an important impact on product satisfaction. Choi (2019) defined customer satisfaction as evaluating the online shopping

experience based on purchasing products or services and showed that the higher the customer satisfaction, the greater the possibility of repeated purchase behavior. If the satisfaction of a product is higher, all aspects of the product are more reliable. Therefore, the higher the evaluation of logistics services, the higher the customer's perceived product value. The current era is an era of competition by providing logistics and distribution. Chou (2014) found that the quality of logistics services has a significant impact on consumers' brand attitudes, and the brand image of a company directly affects consumers' perceived value of the company's products. Therefore, the quality of logistics services will directly affect the experience of consumers and the competitiveness of enterprises. During the raging period of the Covid-19 epidemic, fresh food e-commerce ushered in new development. In fresh food e-commerce, logistics service quality is a key factor in product marketing and maintaining market competitiveness, and the logistics service level will directly affect consumers' purchasing tendency. So, we have:

**H1:** Logistics services positively affect consumer impulse purchases.

The prevalence of social networks has prompted more and more people to express and share their subjective opinions on certain products through social networks. From eating, drinking, and playing to clothing, food, housing, and transportation, from material needs to spiritual needs, reviews of online shopping products have become an important source of information for consumers to understand the true situation of online products (Chakraborty, 2019). At the same time, most consumers obtain and analyze corresponding online reviews before purchasing products as an important reference for purchase (Zhao *et al.* 2019). Product praise rate is closely related to brand reputation and brand recommendations. Apps such as Xiaohongshu and Tanwu will launch ranking lists of the same type of products or services based on product praise rates. The ranking of the list can easily affect consumers' shopping preferences. The higher the product praise rate, the higher the credibility of the product description information provided by the merchant, and the easier it is for consumers to make impulse purchases. Zhao & Peng (2019) found that online reviews will significantly impact users' perceived value, affecting users' purchasing decisions. Deloitte (2012) found that online reviews affect more than 82% of people's purchasing decisions. Chevalier (2006) and others investigated the relative sales of books on Amazon.com and Barnesandnoble.com and found that consumer reviews positively impact product sales. When searching for a certain product type, the higher the sales volume, the easier it is to appear at the forefront of the search page. The easier it is to attract consumers' attention, the easier it is to stimulate blind trust emotions. The higher the historical sales volume, the more advantageous the product's packaging, appearance, performance, and quality, enhancing consumers' perceived value and inducing impulse purchases. For consumers looking for shopping value types, products with a beautiful appearance and exquisite packaging will bring extra pleasure, and people are more likely to make irrational decisions in a happy mood. As sales increase, product reviews will increase, and the authenticity and comprehensiveness of the reviews will increase. Therefore, we have:

**H2:** Product reviews and sale volume positively affect consumer impulse purchases.

With the rapid development of social commerce, consumers' online shopping methods are no longer limited to spontaneously browsing products on e-commerce platforms. E-commerce anchor live broadcasts with goods, overseas purchasing agents, etc., are all purchased through the recommendation of a third party. Chen *et al.* (2019) showed that the emotional trust of recommenders determines impulse buying. Since e-commerce transactions occur and are realized on the Internet, this increases the uncertainty of the transaction. Suppose it is a product recommended by an acquaintance, a trusted e-commerce anchor, or a procurement service out of emotional trust in the recommender. In that case, the buyer will subconsciously believe that the product comes from a guaranteed product from a formal channel, which greatly reduces the perceived risk and causes unplanned purchase behavior. The experiment of Farhadpoor *et al.* (2021) shows that the quality and credibility of information sources will significantly affect users' shopping attitudes and their use of information resources. During the shopping festival, consumers will be exposed to social media product recommendations and social interactions. And even the live broadcasts of well-known e-commerce anchors such as Ya Wei and Jiaqi Li have repeatedly rushed to Weibo hot searches, which maximizes the impact of shopping stimulation and is more likely to produce impulse purchases. The main characteristic of impulse buying is the lack of a deliberate process, a sudden emotion. Therefore, the simpler the purchase decision process, the more likely it is for consumers to make impulse purchases Stern (1962). When a trusted third-party issues product recommendation, consumers reduce the process of inspecting products due to the reduced perceived risk, greatly shortening the thinking time and ultimately leading to impulse purchases. Therefore, we have:

**H3:** Source reliability positively affects consumer impulse purchases.

Bauer (1960) believes that perceived risk includes two factors, the uncertainty of decision-making results and the severity of the consequences of wrong decisions. First of all, the virtual nature of online goods deprives consumers of the opportunity to experience the goods in person, making the goods they buy may be worse than the goods they are willing to pay (Liu, 2020). This information asymmetry in the transaction process increases the perceived risk of consumers. Secondly, even if consumers' awareness of rights has been greatly improved today, many buyers will give up their rights due to the long preparation time for returns, cumbersome procedures, and the need to pay for freight. These risks make more and more people more cautious when shopping online, and a sound customer service system is an excellent way to solve this problem (Skordoulis *et al.* 2018; Gao, 2020). Before the sale, customer service can display product details, introduce products more professionally, accept customer inquiries, and answer patiently to obtain a more authentic and enjoyable shopping experience. Especially in the face of customers who are pursuing shopping value, they may not be very careful about the product itself, but

more about the feeling of the process of purchasing the product. A good customer service attitude will make customers feel respected and have positive emotions. Positive emotions will make customers make decisions faster and more likely to have impulse buying behavior. Tversky & Kahneman (1992), Raman (2019) pointed out that customer service attitude is a key factor affecting female consumers' online shopping attitudes. In addition, the detailed and appropriate introduction of the product by the customer service staff will increase the product's perceived value. When consumers' perception of the product exceeds their initial expectations, their control over rational emotions will be greatly reduced, leading to impulsive purchases. Therefore, excellent pre-sale customer service plays an important role in sales promotion. In addition, the detailed introduction of the product by the customer service staff and the answer to the customer's questions can enable consumers to more clearly judge whether the product meets their needs and reduce the time risk (Ariffin et al. 2018) of returning the product due to dissatisfaction with the real product received. After-sales service protects the rights and interests of consumers through measures such as the seven-day unreasonable return of goods, one compensation for fakes, insured services, and provision of freight insurance. In addition, the customer service staff provide reasonable answers to various questions that consumers have after receiving the goods, reducing consumers' perceived risks when shopping online and allowing consumers to buy with confidence and boldness. So we have:

**H4:** Customer service positively affects consumer impulse purchases.

Data from the National Bureau of Statistics show that in the first half of 2021, the national per capita disposable income was 17,642 yuan. Hence, product price is critical in browsing and purchasing goods, both in the traditional consumer sector and e-commerce. Traditional theory suggests that shopping orientation greatly influences consumers' channel preferences, and shopping orientation can be divided into four categories: convenience, experience, entertainment, and price. Online shopping is attractive to price-oriented customers because they can find functionally identical or similar products at a lower price quickly and easily compared to traditional offline shopping. In addition, discount sales have the advantages of high operability and consumer stimulation, which can quickly increase short-term sales and are one of the most popular promotional tools businesses use during shopping festivals. Donovan *et al.* (1994) found that price discounts induce consumers to make unplanned purchases, and Seiler's transactional utility theory can explain this phenomenon well. The price difference between the discounted item and the reference price gives consumers perceived transactional utility, impulsively purchasing. The greater the perceived transactional utility, the more consumers tend to purchase. In behavioral economics, consumers think more about which goods bring them the most transactional utility when making purchasing decisions, and purchases occur when they receive satisfaction from the transactional utility. Thus, we have:

**H5:** Prices and discounts positively affect consumer impulse purchases.

### Structural Model

Based on the above discussion, this paper uses the Stimulus-Response-Organism (SOR) framework as the theoretical basis to establish a model to reveal how logistics services, product praise rates, product sales, source reliability, product prices, and discounts directly or indirectly affect impulse purchases. Fig. 1 shows the model.

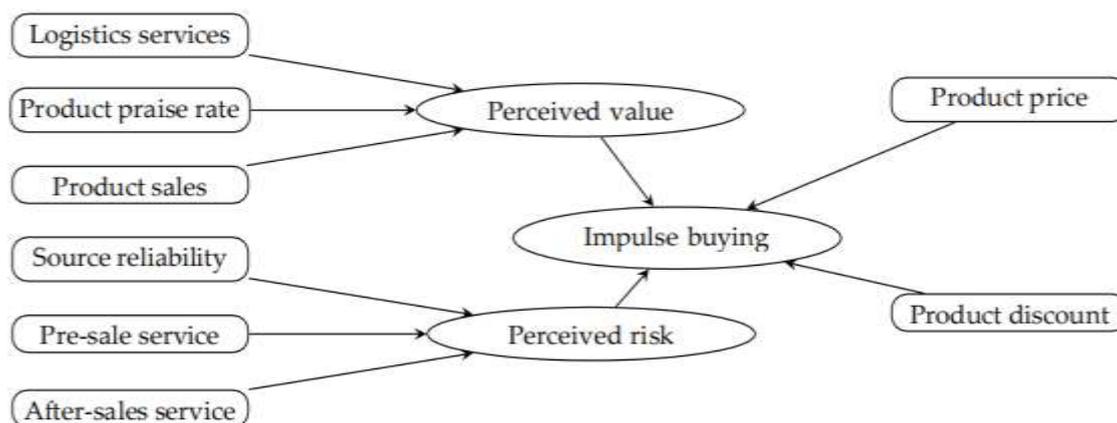


Figure 1: A taxonomy of learning methods used for the customer service system.

Table 1: Sample demographics.

Measure	Item	Frequency	Percentage
Gender	Male	532	44%
	Female	687	56%
Age	<20	274	22%
	20-30	764	63%
	>30	181	15%
Education level	Below university degree	222	18%
	Undergraduate	689	57%
	Master degree and above	308	25%
Income in RMB (monthly)	<1500	544	45%
	1500-3000	502	41%
	>3000	173	14%

### Questionnaire and Data Results

This section will present the questionnaire we use to check our hypotheses and mode and statistically analyses the data collected from the questionnaire to verify our hypotheses and model.

### Questionnaire Design and Data Collection

This study collected data in the form of online questionnaires, designed questionnaires with the help of the “Questionnaire Star” platform, and distributed the questionnaires in the form of links and QR codes through social platforms such as WeChat and QQ. The questionnaire consists of two parts. The first part is the basic information of the respondents, and the second part is all the hypothetical factors that attract and stimulate consumers to make impulse purchases. This questionnaire mainly focuses on the life of online shoppers as the research object; a total of 1,260 questionnaires were issued. By checking the length of time to fill out the questionnaire, judging whether the object of filling out the questionnaire is the same as the research object and setting trap questions, a total of 1,219 valid questionnaires were screened, with a valid recovery rate of 96.75%. Table 1 shows the basic information statistics of the respondent to the questionnaire.

### Common Method Bias

Since the data source of this study’s questionnaire was relatively homogeneous, and the number of respondents between the ages of 20 and 30 was 764, accounting for 60% of the total number of respondents, the data results may be subject to a common method bias. So, this paper uses the Harman one-way test to test for common method bias among the collected sample data. In this study, we use SPSSAU as the statistic analysis tool. The test results show that the commonality values corresponding to all the research items were higher than 0.4, implying that the research items’ information content could be effectively extracted. Furthermore, the results obtained through principal component analysis showed more than one factor with a characteristic root value greater than one, and the percentage of variance explained by the first common factor was less than 40%. From this, we can judge that no single factor controls the total variance in this survey study, and there is no serious common method bias.

Table 2: Results of reliability analysis.

Measurement items	cronbach’s $\alpha$ after deletion of terms
Source Reliability	.719
Logistics Services Rate	.730
Product Sales	.728
Product Praise	.723
Pre-Sales Services	.713
After-sales Service	.714
Product Price	.724
Product Discounts	.737
Overall	.750

Table 3: Results of validity analysis.

KMO		.803
Bartlett's Test	Approximate Chi-Square	1759.342
	Df.	28
	Sig.	.000

Table 4: ANOVA.

Model		Quadratic Sum	Df.	Mean-square	F	Sig.
1	Regression	255	.539 7	36.506	83.816	.000
	Residual	3713.461	8526	.436		
	Sum	3969.000	9751	.456		

## DIALOGUE MANAGEMENT

### Analysis of Data Results

We first conducted reliability and validity analyses on the collected questionnaire data. The results of the analyses are shown in Tables 2 and 3. we used Cronbach's alpha coefficient as the main measure for the reliability analysis of the scale data. After removing items for each measurement factor, the Cronbach's coefficient was greater than 0.7. There were no observations whose removal would increase the Cronbach's  $\alpha$  value. The overall reliability coefficient value was 0.751, indicating that the study data reliability quality is good and can be used for further analysis. The validity analysis of all the measures showed that the KMO value of the overall scale was greater than 0.8, and the significance of Bartlett's spherical test value was less than 0.001, indicating that the study data had good validity and reached a significant level. From Table 4, we can see that  $F = 83.816$ ,  $P = 0.000 < 0.05$ , implying that our model is statistically significant and worth being further analyzed.

### Structural Model Verification

We use SPSSAU to verify the structure model proposed in this paper, and the test results of the structure model are shown in Fig. 2. The test includes the coefficients and their significance, which verifies all the hypotheses we make.

Table 5 shows the results of the hypothesis verification.

## DISCUSSION

This section will discuss how the sellers can use the result of our analysis above.

This study investigates the impact of external factors stimulating consumer impulse purchases by developing a structural equation based on the S-O-R model, and the experimental results show that all of our hypothesis factors are supported by validation.

First of all, the results of this study show that logistics services, good ratings of goods, and sales of goods are mediated by the perceived value, which will all have a positive impact on impulsive buying behavior. The distribution channels of e-commerce platform merchants generally cooperate with outsourcing logistics companies. When choosing a partner company, merchants should consider the company's average logistics delivery time, the damage rate of goods, ratings of delivery personnel, last-mile logistics, etc. The last mile in the city includes issues such as door-to-door delivery and delivery to the delivery point closest to the receiving location(Wang, 2020;Viu-Roig, 2020), which have become one of the main factors in evaluating the quality of logistics.

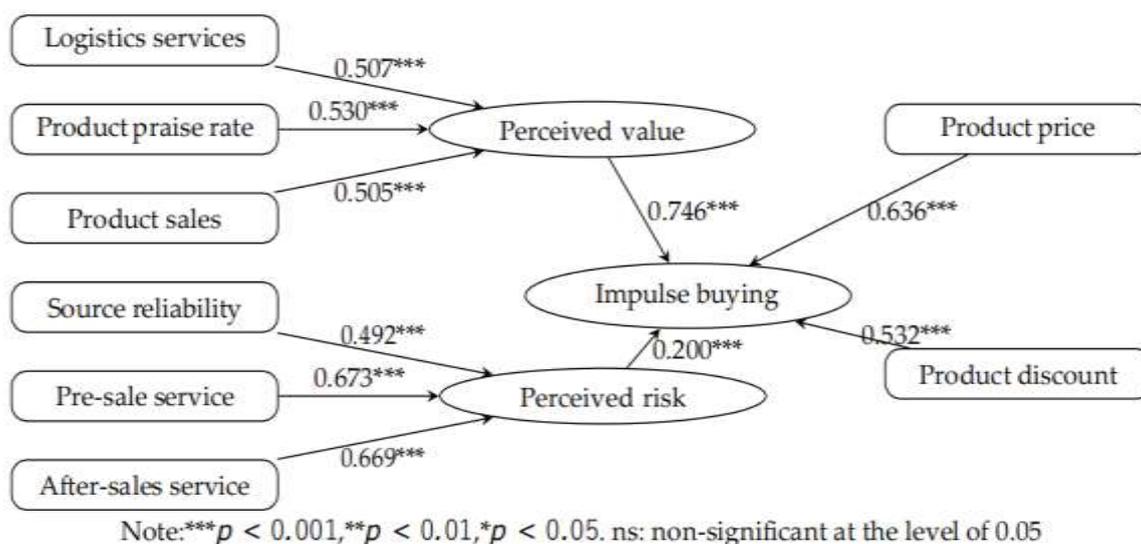


Figure 2: The Research model text result.

Table 5: Hypothetical research.

Items	Hypothesis	Results
H1	Logistics services positively affect consumer impulse purchases	✓
H2	Product praise rate positively affects consumer impulsive purchases	✓
H3	Product sales positively affect consumer impulse purchases	✓
H4	Source reliability positively affects consumer impulse purchases	✓
H5	Pre-sales service positively affects consumer impulse purchases	✓
H6	After-sales service positively affects consumer impulse purchases	✓
H7	Product prices positively affect consumer impulse purchases	✓
H8	Product discounts positively affect consumer impulse purchases	✓

Merchants need to improve the quality of logistics services to enhance customers' willingness to repeat purchases, gain a stable customer base, and achieve longer-term development. It has become popular for companies to conduct sentiment analysis of online reviews on e-commerce sites to understand consumer perceptions of products and services in the business world (Changchit, 2020). Merchants and manufacturers can learn which aspects of the product are inadequate and the deficiencies based on consumers' good and bad reviews. And which aspects are favored by consumers and adjust product performance based on sentiment analysis of online reviews to improve product competition Strength, increase product sales and praise rate.

Secondly, source reliability, pre-sales service, and after-sales service, mediated by perceived risk, all have a significant positive impact on impulse buying. There is a dazzling array of online products, and the same types of products abound. It is impossible for consumers to see all the product information and therefore miss the opportunity to purchase products. Enterprises and merchants should establish their official accounts on popular apps among online users, such as Xiaohongshu, Weibo, Douyin, and WeChat official accounts, to upload product information and preferential activities. At the same time, merchants and businesses can invite reputable e-commerce anchors for promotional sales when they can afford to do so, increasing consumer trust in their goods and making more consumers aware of their brands and products. With the increase in online consumers, especially in shopping festivals, there are too many online inquiries, and many merchants cannot respond in time. Generally, automatic response functions such as "service assistants" are set up. However, "service assistants" can only make fixed responses to regular questions (such as when to ship and return), which may cause negative emotions for customers who want to quickly solve the specific problem, which is not conducive to the development of the online shopping market. E-commerce platforms or companies should choose a more intelligent human-machine dialogue system (Angelov & Lazarova, 2019) such as a human-machine dialogue system based on big data, reinforcement learning, and sentiment analysis. Which can respond to customer messages in time and have a more comprehensive understanding of customer preferences, emotions, and Demands, etc., give high-quality responses to improve customer satisfaction.

Third, in the period of a discount promotion, merchants can learn from Pinduoduo's group buying model. Under the condition of ensuring that each product can at least obtain a certain profit, the greater the quantity, the greater the discount. This can encourage consumers to invite more people with the same needs to join the purchase. Thus, not only can consumers get more discounts, but businesses will also get more benefits.

### RELATED WORK

Other work also investigates what factors may impact customers' online shopping behaviors, but our work is different from them. Chen *et al.* (2019) use signal theory to study how information cues affect online buyers' perception of trust, product attitudes, and impulse purchases. Our work is different from them in the following aspects: 1) we use questionnaires to study how external environmental stimuli directly or indirectly affect consumers' impulsive purchases; 2) we believe that trust and product attitudes will pass through perceived value and perceived risk to affect impulse buying indirectly. Akintan (2019) added the effect of transaction utility when explaining impulse buying behavior in real life. Sinha (2004) proposed that transaction utility is closely related to purchase or sales, indicating the pleasure of financial transactions itself. This paper believes that pleasure will increase the transaction utility of products and stimulate impulse purchases. Audrain *et al.* (2013) believe that each type of product involves a specific purchase strategy in the online environment. According to the game model we constructed, buyers and sellers can better choose purchase strategies and sales. Strategy. The experimental results of Muehlbacher *et al.* (2011) prove that if the product's actual value is more considered when purchasing the product, the transaction utility will become less important. Which can prove that we divide consumers into more concerned about use value and more concerned about purchase. The rationality of value. Companies can analyze their big data on e-commerce websites, such as historical order analysis, overall consumption level analysis, browsing record analysis, etc., to obtain a set of consumer preferences for a product. Combined with the structural model, we proposed appropriately adjusting the weights of environmental factors that stimulate impulse buying in the marketing strategy and making decisions that can achieve the greatest effect.

### SUMMARY

Nowadays, online shopping is one of the major shopping methods, which many factors impact. To help sellers make proper marketing strategies in online shopping festivals, in this paper, we empirically study what factors may impact customers' impulsive purchases. We also construct a structural model for stimulating consumer impulse purchases. The model can help online sellers to obtain a collection of consumer preferences for a particular product through big data analysis of e-commerce websites, such as historical order analysis, overall consumption level analysis, and browsing history analysis.

However, it is worth improving our work in many aspects in the future. For example, it is necessary to consider consumer regret behavior after impulse purchases and minimize consumer return behavior. It is essential because ignoring the results of impulse purchases may waste social resources and negatively affect the company's reputation. Besides, our study is based on e-commerce platforms in China only. We hope that our model can be tested in different cultures in the future. Furthermore, this study only uses an online questionnaire to collect data, which may have some bias. So, in the future, it is interesting to use multiple forms and channels to collect data to see whether our model is still valid. In addition, it is also interesting to study whether different factors may impact impulsive purchases of various consumer groups (e.g., different age groups, different incomes, different regions, and different social circles).

### ACKNOWLEDGMENT

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# Analyzing the Impact of COVID-19 Outbreaks on MIS Students: A Qualitative Approach

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## ABSTRACT

During the breakout of coronavirus disease (COVID-19), many schools worldwide have enforced a policy of distance education. The Taiwanese students also experienced long hours of learning by using smart technologies for the first time. MIS education is a career preparation for IT professionals who use smart technology in organizations. IT professionals with MIS education backgrounds may have important roles when facing COVID-19. Moreover, many MIS students will become IT professionals and join the workforce for combatting the pandemic using smart technologies with their background of MIS education. This study intends to construct theories that depict the relevance among MIS education, IT professionals, and smart technologies in the confrontation of the COVID-19 pandemic. By using in-depth interviews with MIS students and recent MIS graduates, the possible impacts of COVID-19 outbreaks are analyzed. The results could provide reflective insights for MIS education providers, human resource units, IT firms, and organizations confronting COVID-19 outbreaks.

*Keywords:* Management information system, education, IT professional, COVID-19, metaphor.

## INTRODUCTION

The year 2020 was a difficult time for the whole world. Since the start of 2020, the world has been facing the epidemic of coronavirus disease (COVID-19). To prevent infectiousness, many countries have restricted transportation, grounded airlines, closed public facilities, blocked traffics, sealed cities, and quarantined residents, making the provision of goods and services extremely difficult (Whitelaw *et al.*, 2020). During this abnormal period, electronic governments and businesses taking advantage of digital technologies provide emergency relief to the people and organizations in need at home or worldwide under this disastrous situation (Tuli *et al.*, 2020).

IT professionals are key actors in the utilization of digital technologies. They are people with IT skills to help the confrontation of contingencies for governments, enterprises, and other organizations. Therefore, IT professionals could be an important linkage resource between digital technologies and the COVID-19 confrontation. Furthermore, many IT professionals have an educational background in management information systems (MIS). Their professional careers start with the knowledge obtained from MIS education. Thus, MIS students (i.e., the future IT professionals) are also relevant in the connection between digital technologies and the confrontation with COVID-19.

Each year, many students who graduated from university MIS (or similar) education programs join the workforce of IT professionals and play a pivotal role in the utilization of digital technologies to serve in various sectors of organizations. With this educational background in the MIS discipline, they are expected to be confident and perform their duties with satisfying results. However, the real world is always full of various challenges. Starting from the year 2020, MIS graduates are facing one more challenge that is not seen in human history: the outbreak of COVID-19.

Moreover, the COVID-19 outbreak triggered many schools worldwide to enforce a policy of distance education. The Taiwanese students also experienced long hours of learning by remote technology for the first time. This policy also caused many Taiwanese students studying abroad to come back to Taiwan temporarily. Most of them chose to come back to their family and friends to avoid facing the pandemic alone. This experience of disruption in life may have a long-term impact on their perceptions of learning and future career.

However, despite these possible connections, the research on the impact of COVID-19 outbreaks on MIS students so far is very scant. Therefore, the objective of this research is to investigate and clarify the possible impacts. This study aims to analyze the impact of COVID-19 outbreaks on MIS students and deliver possible implications to MIS educators and IT managers.

The paper explains first the research setting for this study. Following that, the process of data collection and the results of data analysis are elaborated. Finally, discussion, implications, and conclusions with suggestions are provided.

## METHOD

### Research Setting and Data Collection

This study intends to construct a theoretical framework that depicts the relevance among MIS education, IT professionals, and smart technologies in the confrontation of the COVID-19 pandemic. A grounded theory approach for data analysis is chosen

because of its specific objective of building a theoretical framework from qualitative data and interpretative analysis (Corbin & Strauss, 1990).

Data for this study were collected through formal interviews, informal dialog, and archived data. Data collection activities were started in the middle of April 2021 and took about thirty days to complete. Table 1 exhibits data collection methods.

Table 1: Data collection.

Data source	Data collection process
Formal interviews	<ul style="list-style-type: none"> <li>● Six formal interviews, each took about eighty minutes</li> <li>● Seventeen follow up video conferences for data clarification</li> <li>● Interviewees include MIS students and recent graduates</li> <li>● We have ruled out the students from our affiliated school</li> </ul>
Informal dialog	<ul style="list-style-type: none"> <li>● Five conversations with two MIS professors, one of which has been a department chair</li> <li>● Three conversations with a corporate CIO and an MIS team</li> <li>● Four conversations with a senior VP of a recruitment website</li> </ul>
Archived data	<ul style="list-style-type: none"> <li>● MIS education program descriptions on the university websites</li> <li>● Recruiting advertisements for IT professionals</li> <li>● Attending two public, corporate conferences held by IT companies</li> <li>● Discussion of life and social experience on social media</li> <li>● News and commentaries about COVID-19 outbreaks and social phenomena</li> </ul>

Source: This study.

### Recruiting Procedure

This study used purposive sampling with a snowballing method to recruit participants. In the sampling, we have ruled out students of our affiliated school. Data collection by interviews was conducted in April of 2021. Totally six interviewees with diverse backgrounds from different universities in Taiwan and USA participated in this study. At the time of the interviews, some of them were senior MIS students, some of them were master-level MIS students, and the others were recent graduates from MIS programs and worked for less than two years. The participants are as shown in Table 2. They were interviewed separately. Each interview lasted about eighty minutes.

Table 2: Participants description.

Case name	Status at the time of this study	Affiliated school location
Student Chen	<ul style="list-style-type: none"> <li>● Senior undergraduate MIS student</li> <li>● Studied accounting before transferring to MIS</li> <li>● Part-time work in pharmacy sector for one year</li> </ul>	Northern Taiwan
Student Fang	<ul style="list-style-type: none"> <li>● Senior undergraduate MIS student</li> <li>● Assisting a project about cloud security and social media privacy</li> <li>● Summer practicum at a medical equipment manufacturer</li> <li>● Summer practicum at an online retailer</li> </ul>	California, USA
Student Guo	<ul style="list-style-type: none"> <li>● First-year master level MIS graduate student</li> <li>● Two years of working experience in the finance sector</li> <li>● Part-time working experience at a gym</li> <li>● Self-study of herbal medicine</li> </ul>	Northern Taiwan
Student Lin	<ul style="list-style-type: none"> <li>● Second-year master level MIS graduate student</li> <li>● Working on a thesis about comparing agile development model and waterfall model</li> <li>● One year of working experience in the media sector</li> <li>● Part-time volunteer service in the healthcare sector</li> </ul>	Texas, USA
Student Wu	<ul style="list-style-type: none"> <li>● Graduated from undergraduate MIS program</li> <li>● Working for two years in the MIS unit of the manufacturing sector</li> <li>● Traveled to China and Korea several times for work assignments during the COVID-19 outbreak</li> </ul>	Northern Taiwan
Student Yeh	<ul style="list-style-type: none"> <li>● Graduated from master MIS program</li> <li>● Master project of using neural network and data mining to analyze supply chain data</li> <li>● Working for one year in the MIS unit of the retail sector</li> <li>● Six months of civil service in a hospital on an outer island of Taiwan</li> </ul>	California, USA

Source: This study.

### Interview Process

Semi-structured interviews were conducted with the sampled MIS students. Data were recorded through a semi-structured guideline as a starting point, followed by open-ended and unstructured interviews. The semi-structured interview guideline is listed in Table 3.

During the interviews, the interviewees were invited to freely express their thoughts about their MIS education, becoming an IT professional, the current COVID-19 situations, and any other related thinking.

From April to May 2021, six formal interviews were conducted, each taking about eighty minutes. The languages used in the interview were Chinese and English. The locations of the interviews were mainly in northern Taiwan.

Table 3: Semi-structured interview guideline.

Sequence	Topics
1. Opening	
1	Introduction
2. Learning aspect	
2.1	Reasons of studying MIS
2.2	General perception about MIS education
2.3	Additional thoughts
3. Working aspect	
3.1	Interest of becoming an IT professional
3.2	General perception about IT professional
3.3	Additional thoughts
4. COVID-19 aspect	
4.1	General perception about COVID-19
4.2	Impacts of COVID-19 to MIS education
4.3	Impacts of COVID-19 to IT professional
4.4	Additional thoughts
5. Ending	
5.1	Acknowledgement and other suggestions

Source: This study.

### Data Analysis

The data of this study were analyzed after the data collection stage. The interview files were transcribed from notes to text to form the significant statements as the data for analysis in this study. Data clarification was made by contacting the interviewees when there were ambiguous or missing contexts. After reading the transcribed text, the researcher extracted the meanings of perceptions and experiences of the interviewed students. Iterative meanings were collected, analyzed, coded, and organized into themes.

## RESULTS

Data from the individual interviews were analyzed and classified into three themes: MIS education as an adaptable incubator, IT professional as an agile integrator, and COVID-19 epidemic as an anguishing intruder.

### MIS Education as an Adaptable Incubator

Excerpts of the interview results of MIS students' perceptions about MIS education were analyzed, as shown in Table 4. Three attributes were identified for students' perceptions about MIS education: adaptable content, continuous learning, and intellectual preparation.

Table 4: MIS students' perception of MIS education.

Interview excerpt	Coding	Theme
MIS education, to me, is fundamental learning of IT and its application. The knowledge is updated very quickly, so we have to keep learning by ourselves anytime and anywhere we can.	Intellectual preparation Continuous learning	An adaptable incubator
I think of my MIS education as training to become a knowledgeable person of information technology and management who is adaptable to new trends.	Intellectual preparation Adaptable content	
Maybe it is because of the fast-changing pace of this discipline. I feel it is like a life-long learning task. We have to continue learning by ourselves even after graduation. The goal is to prepare ourselves for challenging IT tasks. Learning in the clouds is quite popular now. You can find many free courses and training programs on YouTube and other websites. It is your own responsibility to keep learning.	Adaptable content Continuous learning Intellectual preparation	

After the COVID-19 outbreak, most of the time, we use distance learning and take courses online. At first, I was not used to studying this way, but now I have gotten used to it and think it's quite convenient. I can use my mobile phone to participate in courses. Thanks to smart technologies.	Continuous learning	
The school teaches you the foundation of knowledge. It is like opening the door for you. Then you have to go further by yourself. Because new AI and deep learning knowledge are coming up so fast, we need to visit our library and websites very often and keep learning whenever we have time.	Continuous learning Adaptable content	
Fortunately, we have a pretty good digital library in our school. I think it saves me much of the time to find the innovative status of IT-related topics. For example, our professors would ask us to log into the school library and search for the recent development of IoT and blockchain.	Adaptable content	

Source: This study.

This theme refers to students' experiences and viewpoints about the content and value of their MIS education.

### IT Professional as an Agile Integrator

Excerpts of the interview results of MIS students' perceptions about IT professionals were analyzed, as shown in Table 5. Attributes identified in this topic include digital infrastructure, agile servicing, and technology integration.

Table 5: MIS students' perception of IT professionals.

Interview excerpt	Coding	Theme
IT and IT professionals are seldom regarded as a leading role. It is the infrastructure. It is much like a supportive role. However, it is a necessary supportive role for all the other services.	Digital infrastructure Technology integration	An agile integrator
Manufacturing, finance, retail, healthcare, and even government all require the infrastructure provided by IT. I think of IT professionals as enabling integrators of information systems. Without them, IT is just a piece of hardware.	Digital infrastructure Technology integration	
My understanding about IT professionals is that they often work under very tight schedules because all the others would be based on them to function. IT is like infrastructure to everything.	Digital infrastructure Agile servicing	
It seems to me that they (IT professionals) don't need to have deep knowledge of every kind of technology, but they need to know how to quickly put things together to work. Smart technologies are advancing very fast, and they have to keep up with the technologies and practice them.	Technology integration Agile servicing	
In this profession, we need to deliver innovative services efficiently under time constraints and changing requirements. The user preferences and demands are constantly changing, so we usually work with learning-by-doing to quickly respond to the changing world. So for the COVID-19 situations, we need to work around the needs of our clients because their situations have also changed suddenly. We need to think and act ahead of our clients.	Agile servicing	
During the COVID-19 pandemic, our professors invited some graduates now in the healthcare industry to our class and shared how they helped mitigate the situation with the integration of smart technologies.	Technology integration	

Source: This study.

This theme refers to students' understanding of IT professionals from classroom knowledge and previous experiences to the practicum or part-time works by the observation and practice in the workplace settings.

### COVID-19 Epidemic as an Anguishing Intruder

Excerpts of the interview results of MIS students' perceptions about the COVID-19 epidemic were analyzed, as shown in Table 6. The identified attributes in this topic were: lifestyle disruption, pervasive anxiety, and public uncertainty.

Table 6: MIS students' perception of COVID-19 epidemic.

Interview excerpt	Coding	Theme
People were wondering how long it (COVID-19) would last, how much food supply is left, and where to get a mask. My parents run a small retail store in the south (of Taiwan). During the pandemic, they really worried about the supply of merchandise and the stop of customers.	Public uncertainty Pervasive anxiety	An anguishing intruder
Most of us have to stay home or stay in the dorm. Most of our courses were switched to distance learning. We were not allowed to have indoor meetings and activities.	Lifestyle disruption	
The virus can continue to evolve and mutate. They seem to be unstoppable. So far, no real cure is available. We were advised to avoid physical contact with our family members, classmates, and friends. This is really annoying.	Pervasive anxiety Lifestyle disruption	
There are lots of fake news and false messages of the pandemic situations around. This is often amplified by social media. I think social media need to be used more carefully in times like this. So, I think COVID-19 breakout is not just the spread of physical viruses but also the spread of cyber viruses.	Public uncertainty Pervasive anxiety	
COVID-19 breakout makes me pause my usual activities and think about life, our environment, and our community. I wonder if there is something I can do to help. You have to respect human lives. You have to respect the environment. You have to respect the ecology. These are what COVID-19 taught us.	Lifestyle disruption Pervasive anxiety	
During this period, we rely on various information systems and services to cope with the situation. Online shopping, distance learning, remote conferencing, and work at home have become common for almost everyone. This scenario makes me feel like living in a world of virtual reality.	Lifestyle disruption	

Source: This study.

This theme refers to students' cognition and experiences about the COVID-19 outbreaks. They narrated their encountering with the disastrous pandemic and the disruption and change of their lives.

### Summary of Findings

Table 7 exhibits a summary of the findings. In our coding process, metaphors were adopted as a media of scientific communications. Recent research in cognitive science has demonstrated that metaphors can shape the way people think and initiate scientific research ideas through novel comparisons between natural phenomena and everyday experiences (Taylor & Dewsbury, 2018; Thibodeau *et al.*, 2017). Metaphors are also commonly adopted in MIS studies. For example, "cloud" computing, "waterfall" model, and data "warehouse" are all metaphors for understanding abstract concepts of information technologies.

Table 7: Summary of MIS students' perceptions.

Theme	Perception	Components
MIS education	As an adaptable incubator	<ul style="list-style-type: none"> <li>● Adaptable content</li> <li>● Continuous learning</li> <li>● Intellectual preparation</li> </ul>
IT Professional	As an agile integrator	<ul style="list-style-type: none"> <li>● Agile servicing</li> <li>● Digital infrastructure</li> <li>● Technology integration</li> </ul>
COVID-19 epidemic	As an anguishing intruder	<ul style="list-style-type: none"> <li>● Lifestyle disruption</li> <li>● Pervasive anxiety</li> <li>● Public uncertainty</li> </ul>

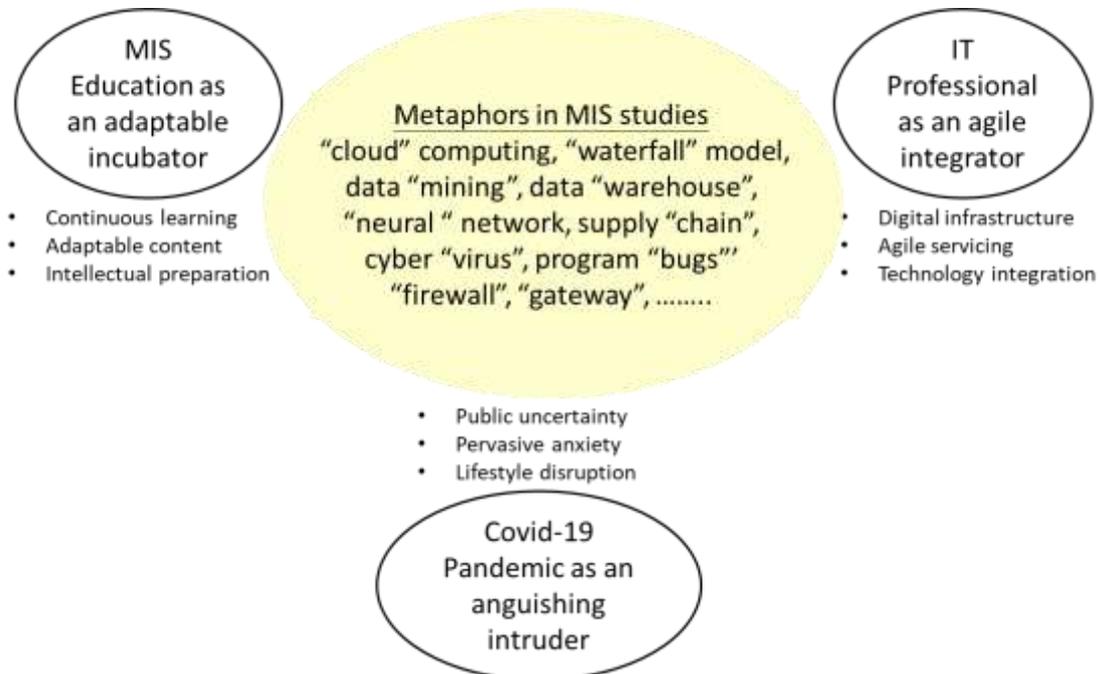
Source: This study.

## DISCUSSION

The results can be further discussed toward five focal points: meanings of the metaphors, linkage of the perceptions, remedy of the pandemic impacts, the role of smart technologies, and the possible transitions. These focal points are illustrated as follows.

### Understanding the Metaphors

As displayed in Figure 1, metaphors are widely used in MIS study and the IT profession to convey abstract concepts by familiar things in life. In our analysis of data, the students' perceptions of MIS education, IT professional, and COVID-19 outbreak were also expressed with metaphors such as "an adaptable incubator," "an agile integrator," and "an anguishing intruder." We presented these metaphors to various MIS students, IT professionals, and scholars (listed as informal dialog in Table 3) and obtained positive responses. They also suggested that in many scenarios of communicating with IT professionals, using metaphors is more profound and inspiring. The three metaphors we adopted, incubator, integrator, and intruder, also fit the IT culture and lingo.

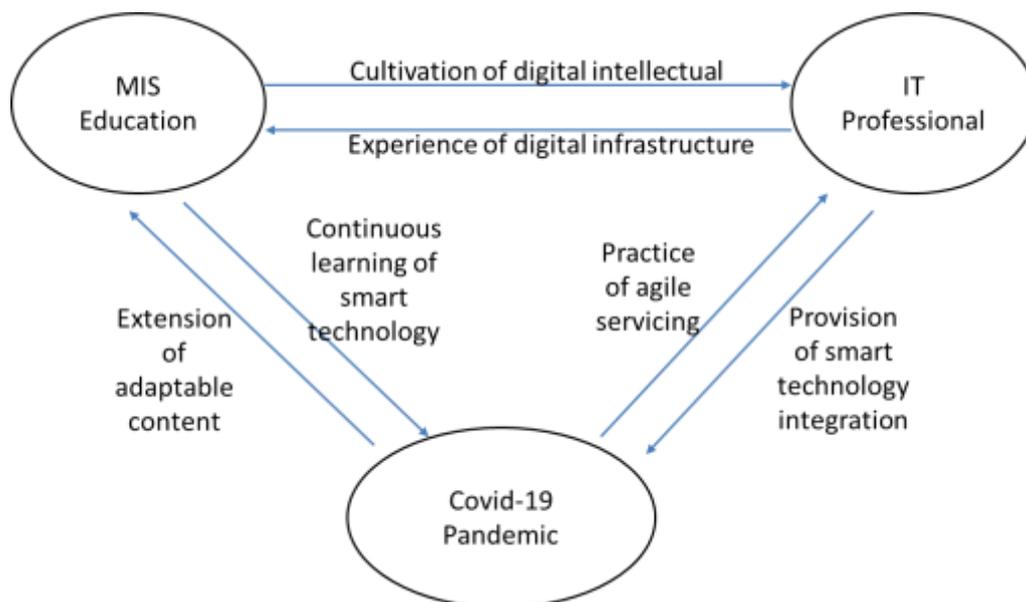


Source: This study.

Figure 1: Understanding the metaphors.

**Linking the Perceptions**

Figure 2 shows a conceptual framework linking the students' perceptions of MIS education, IT professionals, and the COVID-19 outbreak. These linkages were constructed in the coding process by relating the attributes of the perceptions in Tables 6-8. For example, MIS education is an incubator for cultivating the digital intellectual of IT professionals, while IT professionals provide experiences of the work on digital infrastructure. Also, the COVID-19 pandemic is expected to extend the adaptable content of MIS education and stimulate effective practices of IT professionals.

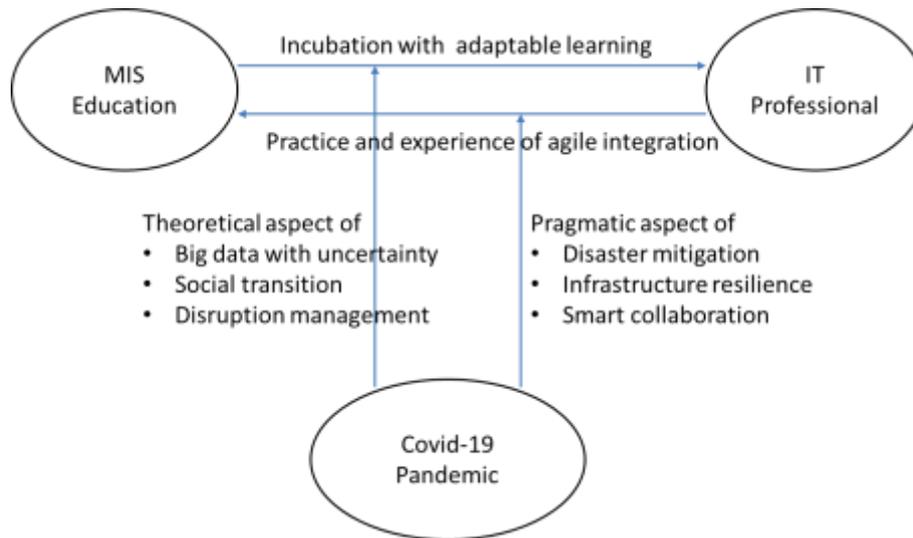


Source: This study.

Figure 2: Linking the perceptions.

### Remedying the Intruder

Figure 3 displays a framework that elaborates the challenges of the COVID-19 outbreak on the connections between MIS education and IT professionals and the stimulation of topics for MIS learning and IT practices.



Source: This study.

Figure 3: Remedying the intruder.

COVID-19 outbreaks have caused lifestyle disruption, pervasive anxiety, and public uncertainty. For MIS education, these dimensions could activate the study, such as big data with uncertainty, social transition, and disruption management. For IT professionals, these dimensions should intensify the practices of infrastructure resilience, disaster mitigation, and smart collaboration. Since the pandemic will not vanish soon, this research and practice will also continue.

Furthermore, the experience of facing COVID-19 is highly personalized and diversified. Everyone may be dealing with different problems and coping with different situations. The decision-making is required to adjust dynamically with the fast-changing environment. Therefore, making individual life transitions facing COVID-19 becomes a challenging problem.

## IMPLICATIONS

### Implications for MIS Educators and Researchers

MIS students perceive MIS education as an adaptable incubator. This implies they are aware of the fast-changing pace of the IT field and the multi-discipline nature of management. They understand the importance of continuous learning for knowledge upgrades. The content of the education needs to be adaptable to environmental changes and contingent situations. MIS education is to prepare the students toward caring intellectuals of IT and management.

The outbreak of COVID-19 incurs public uncertainty, pervasive anxiety, and lifestyle disruption. These disastrous effects will last for years. However, the pandemic also invoked great attention from IT-related academics and stimulated the reflective thinking of MIS researchers. As the relevance between the COVID-19 outbreak and MIS education programs increases, the pandemic situations will expand the knowledge domain and research area of MIS. Case studies and scenario analyses are a starting point for MIS students. The analytics of social pandemic big data is a topic combining theory and application (Bossé & Solaiman, 2018). In particular, the students are aware of the concepts of ethics and social responsibility. They expressed their volition to help with the resolution of the situation. Therefore, MIS educators may consider enhancing the discussion of topics such as big data with uncertainty (Bossé & Solaiman, 2018; Hariri *et al.*, 2019; Weng, 2020a), social transition (Haimson, 2018; Haimson *et al.*, 2021), and disruption management (Giuntella *et al.*, 2021; Zheng *et al.*, 2021).

### Implications for IT Professionals and Managers

Our results indicated that MIS students perceive IT professionals as agile integrators. In the interview dialogues, IT professionals are perceived as enablers of digital infrastructure. On top of this infrastructure, they can efficiently develop and deploy various services used by government units, manufacturers, retailers, healthcare providers, and other sectors. They are the integrators of innovative technologies for corporate and personal users (Weng & Lin, 2015). The practice and experience of IT professionals are valuable reference models of careers for MIS students. Moreover, in recent years various industry sectors are gradually upgrading into new paradigms, such as Industry 4.0 for manufacturing (Lasi *et al.*, 2014), Fintech for finance, smart healthcare (Wang *et al.*, 2018), smart retail (Weng, 2020b), and smart tourism (Koo *et al.*, 2017), among others. These industrial upgrades require the services of IT professionals to provide smart technology-empowered solutions. However, the outbreak of COVID-19 presents an unforeseen challenge to all of these industries.

For IT professionals and managers, the COVID-19 outbreak provides alerting reflection on the IT community. Whenever there is an ecological, economic, or social catastrophe, digital infrastructure becomes a critical supportive resource to continue human activities. The future practices of IT will need to strengthen competencies in contingency handling, disaster prevention, and mitigation (Ardito *et al.*, 2021; Bundy *et al.*, 2017; Reuter *et al.*, 2018), change management, and critical digital infrastructure protection (Assaf, 2008). Moreover, since IT-enabled remote collaboration will be the frequent working mode under pandemic situations, IT professionals also need to develop efficient mechanisms for productive collaboration (Weng, 2021).

### CONCLUSIONS

Our goal is to investigate how MIS students perceive the meanings and connections among their MIS education, IT professionals, and COVID-19 confrontation. A cohesive linkage among theoretical knowledge, technical skills, professional competencies, and situational problem solving is critical for MIS students' success in future careers, especially in this unusual time of the disastrous pandemic. Providing quality transition paths of practice and experience for MIS students is vital to the development of commitment and competent IT professionals facing real-world challenges. We hope these findings will not only help MIS educators fully understand the educational effectiveness of current MIS education programs but also provide recommendations for managers of organizations in their efforts to recruit and train newly graduated IT workforce.

Furthermore, although this study reported meaningful implications regarding MIS students' perceptions of MIS education, IT professionals, and COVID-19 outbreak, the validity of a proposition could not be firmly established on the basis of a single qualitative study. Further studies on this topic with other research methods and participants are recommended. Such research will help accumulate more empirical evidence for assessing and validating the results of this study.

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## Augmented Reality Applied in Road Excavation System of Government

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### ABSTRACT

As one of the presentative novel technologies in recent years, Augmented Reality (AR) has gotten the ROC government's attention, and thereby the AR-related applications have been taken into official account in facilitating citizen life. In this research, first, a sort-out of the definitions and the scope of three types of Realities—AR, VR, MR—will be offered to tell the much more realistic dimension of AR. Under the official road excavation context in X city via observation method, second, specific AR applications will be proposed by illustrating it in the pre-excavation, the excavation, and the post-excavation phases, respectively. By cross-referencing between the official road excavation system and public infrastructure pipeline databases, third, the related data of pipeline maps could endow the current AR positioning with better accuracy and directionality.

*Keywords:* Augmented reality, observation method, road excavation, public infrastructure pipeline databases.

### INTRODUCTION

With the pioneering combination of the physical environment and virtual squares, “The Sword of Damocles” proposed by Sutherland in 1965 is widely regarded as the first AR application (Sutherland,1965). Nowadays, AR applications have been extended to various domains. For example, Boeing uses AR to reduce both the error rate and the operation time of wire deployment, which indeed brings out improved safety and the lower manufacturing cost of airliners (DIGITIMES, 2021). Similarly, the head-mounted display (HUD) adopted by the military is an AR device, integrating aircraft information and physical space, which enables fighter pilots to make decisions faster. Possessing the click-and-mortar nature, noticeably, AR shows up in not a few interactive games like EyePet (launched by Sony) or Pokémon Go (developed by Niantic). In comparison with such flourishing commercial AR applications, the ROC governmental AR applications still remain the initial stage. Even though one of the municipal governments, X-city, has tried to figure out a proper AR application to engineering planning that might alleviate the disturbance of traffic jams and inconvenience resulting from road excavations, it is actually an initial scheme with sparse content. Therefore, a further detailed scheme of the AR applications to the engineering planning of road excavation would be the main idea of this research, thus improving the engineering quality of road excavation as well as eliminating the excavating disturbance to citizen life.

Considering the inextricable linkage among all the underground pipelines, including wires, gas pipes, water pipes, and telecommunications pipes, any forms of road excavations, such as emergency repair, major disaster, new construction, even the establishment of a national freeway, should draw up a prudent plan before each engineering in case of any possible false excavation. Since the image of the underground pipelines presented by AR could offer a larger dimension of visibility, from 2D to 3D, it reaches a more concrete and precise simulation of excavating engineering planning. In this case, the scheme of AR applications to excavating engineering planning will be separated into three phases as follows: pre-excavation, excavation, and post-excavation. Before road excavation, AR will present the corresponding location of the underground pipelines to achieve an ideal deployment; during road excavation, mis-digging could be avoided by applying an AR device inter-comparing with the physical environment; after road excavation, 3D pipelines shown by AR in checking pipeline collisions could validate the correctness and the rationality of the pipeline information. In addition, the data gathered by cross-referencing between official road information systems and public infrastructure pipeline databases will enhance the current AR positioning with better accuracy and directionality.

Basically, in the second part of this research, we discuss the definitions and examples of AR and other realities; the third part is methodology; the AR applications to road excavation are illustrated in the fourth part; the final part is the conclusion.

### LITERATURE REVIEW

Augmented Reality (AR) is an imaging integration of virtual objects and the real world. Azuma (1997) argues that AR consists of 3D, instant interaction, and the combination of virtual reality and physical reality. So far, AR has been widely applied in different industries. In the medical field, for instance, AR serves for surgical simulation, while in-game industries, certain interactive AR games, such as Father.IO designed by Proxy42, a First-Person Shooting (FPS) game integrating reality and virtual weapons, have been launched by swarms of game companies.

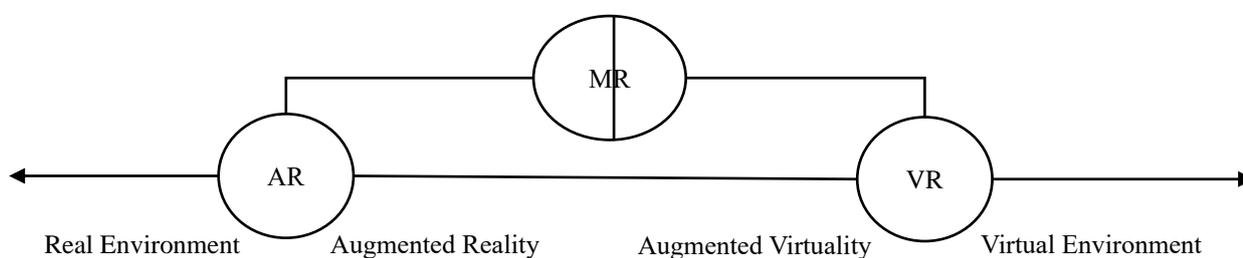
Simulated by a computer system, Virtual Reality (VR) itself is a 3D virtual world providing simulated senses of sight, hearing, and touch to users who can accordingly grasp immersive and realistic experiences. With the 3I characteristics of Immersion, Interaction, and Imagination (Burdea & Coiffet, 1994), VR accentuates the leading role of humans in virtual systems. That is, the information processing model of humans toward computer systems has evolved from external observation to internal immersion. In the virtual world of Second Life (developed by Linden Lab), for example, Users can create characters, called residents, who can not only walk around, socialize with other residents but also participate in individual or group activities and transactions.

Integrating physical sensation into a virtual environment, Mixed Reality (MR) has brought out the interactive coexistence of the real and the virtual objects. For example, the flight simulator provides a simulated cockpit of equal proportion, including a real flying setting, a virtual sight, and hydraulic or electric driven systems to achieve the reenactment of piloting sensation as genuine as possible (Milgram & Kishino, 1994). Signifying single or multiple episodes, Substitutional Reality (SR) is a visual imaging projection of existence belonging to an arbitrary moment, no matter virtual or physical, past, present, or future. Compared with AR and VR, SR need not follow the linear timeline; instead, it could refer to single or infinite timestamps simultaneously.

Generally speaking, AR is a technology based on the real world's photographic image upon which computer information is superimposed; it aims to provide specific sensory information at a specific time and place, that is, augmenting virtual data in physical reality. Oppositely, VR is a virtual space generated by a computer system in which physical reality is duplicated and represented. Via the movement and interaction operated by the controller or keyboard, the VR users easily immerse themselves in the simulation.

Assimilating the real and the virtual, MR creates a new world with new visibility where physical objects and digital objects can be coexisted and interacted in real-time. To a certain degree, MR has expanded the comprehensive application of reality and information. Bathing in the MR environment of multi-dimensional information by equipping various sensors, users meet their expected perception and recognition through the simulating interaction directly with MR settings. Different from all the others, SR is neither based on specific reality nor accommodated specific dimensional objects. Referring to non-specific time or space is the unique feature of SR that sets it apart from other realities. All the realities mentioned above are sorted by their dimensions and shown in Figure 1.

In summary, the characteristic that AR attaches utmostly to the physical reality is geared towards the official need of real-time integration of virtuality and reality. That is the reason this research proposes applying AR to the engineering planning of current road excavation.



Source: Revised from Milgram & Kishino (1994).

Figure 1: Types of reality.

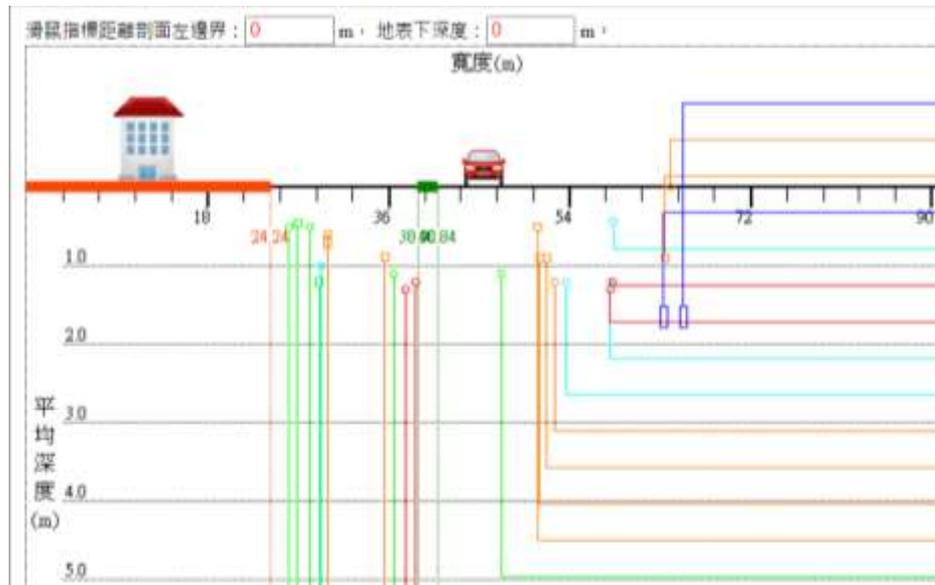
## METHODOLOGY

Compared with the interview method, that restricts the imagination of the interviewees because of the interview questions. Therefore, if a system analyst designs the system based on the opinions collected from interviews, the system creativity is very likely to be limited, without the significant innovation or inventive ideas. As Henry Ford said, before a car is manufactured, when he asked people about what kind of transportation they need, almost everyone's answer is a faster horse. Therefore, the observation method is adopted to determine the AR application in the official road excavation system.

Ciesielska *et al.* (2018) classified the observation method into three categories as follows: (1) participant observation: researcher immerses himself in a specific culture for a long period of time; (2) non-participant observation: researcher keeps being as an outsider while acquiring what is needed; (3) indirect observation: researcher relies on the observations done by others. An important principle of participant observation is that researchers do not only perform observations but also need to participate in the organization in some way as their roles. By carrying out the participant method over two years, this research attains the anticipated collection of the observation data gathered from different special municipalities. In this case, data collection itself involves daily routines and special events, including road excavation systems, policies, self-government ordinances, and standard operating procedures.

## APPLICATIONS

Traditional pipeline maps are presented in the form of 2D overlooking perspective, rooted on the electronic maps, which has its limitations in the context of road excavation. For example, due to the flat view angles, it is not easy to show the spatial distribution, obstacles, and conflicts of pipelines in the 2D modus. Even from the point of side view, as shown in Figure 2, the spatial structure and the direction of pipelines cannot be presented. In addition, because the 2D presentation only gives the partial and specific information of pipelines, the global and spatial analysis is hard to achieve, which makes it difficult to observe pipeline obstacles and resolve pipeline conflicts properly. In order to provide a holistic perspective of pipeline spatial structure in the real environment, AR comes into being. Compared with the 2D pipeline maps, AR could be applied in the actual environment to show the spatial structure of pipelines in the 3D modus, which could present pipeline distribution, pipeline obstacles, and pipeline conflicts properly. Moreover, the AR application in underground pipelines may give feedback on the correctness and the rationality of public infrastructure pipeline databases.



Source: This study.

Figure 2: Side view of 2D pipeline maps.

In the pre-excavation phase, first, AR can be used to present the current distribution of the underground environment, especially the complexity and the danger among crowded pipelines (e.g., oil or gas pipelines), as shown in Figure 3. Superior to the conventional planimetric sight, the stereoscopic image formed by AR offers larger visibility to the construction units that can make better engineering planning through a more sophisticated calculation—cubic meter by cubic meter—to get more convincing constructing costs and schedules.



Source: This study.

Figure 3: AR applied in the pre-excavation phase.

Second, the mis-digging of pipes during road excavations has always been an issue that concerns the officials most due to its high risk of resulting in serious damage. Limited to the invisibility of underground pipelines, the previous constructing units relied either on luck or on constructing experience to reduce mis-digging. Fortunately, the public infrastructure pipeline databases of the ROC government have kept on developing and so far reached millions of pipeline maps with transparent data standards (Construction and Planning Agency, Ministry of the Interior, 2020). Derived from public infrastructure pipeline databases, the bountiful pipeline maps confer quite enough foundations where the artful 3D images formed by AR can be embedded in almost seamlessly. Upon specific areas with highly concentrated pipelines, such AR images embedded in the pipeline map matter a lot because they can tell the underground physical environment correspondingly in great detailed width and depth. Synchronously executing during road excavation via an official exclusive App operated in a mobile device, the prudent cross-comparison between the AR simulating images and the solid pipeline spot delivers effectively the real-time information of physical pipelines (shown in Figure 4). Taking advantage of this elaborate AR application in pipeline maps, the danger of road excavation and the inconvenience caused by mis-digging would be eliminated not entirely, at least partially.



Source: This study.

Figure 4: AR applied in the excavation phase.

After road excavation, third, the AR application in underground pipelines somehow could answer to the correctness and the rationality of public infrastructure pipeline databases. Trapped by the flat angle of vision, in fact, the preceding 2D image gave a little guarantee to the accuracy of pipeline maps of public infrastructure databases. As opposed to a 2D image, the 3D image formed by AR indeed constructs larger visibility which allows more latent pipeline conflicts to be found and checked cautiously in a detailed picture, as shown in Figure 5. Likewise, the examination of engineering execution and pipeline maintenance, or the evaluation of underground security, could depend on related AR applications to a certain degree.



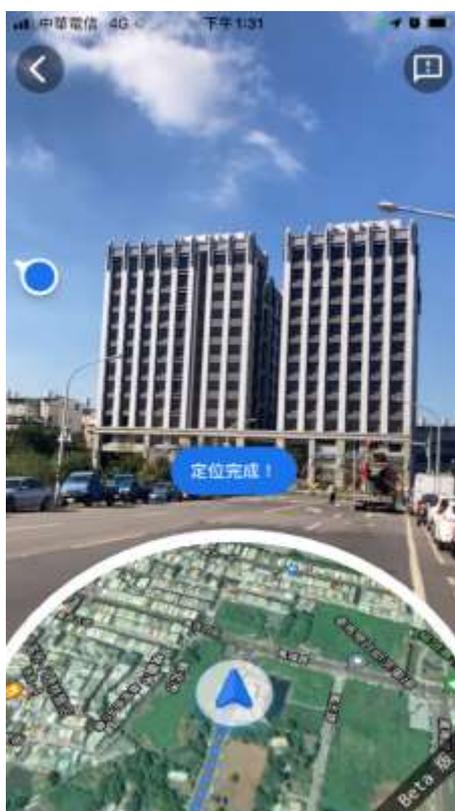
Source: This study.

Figure 5: 3D pipeline conflicts.

It is worth mentioning that AR positioning hasn't attained entire perfection yet. Actually, there are several meters of deviation of AR positioning now applying to commercial mobile devices GPS, which would be an unacceptable inaccuracy applying in road excavation. Such deviation of AR application in road excavation equals a latent threat. Misled by this deviation, any excavation upon a road with a gap pipe only several meters nearby, for example, is very likely to get a mis-digging. Meanwhile, the uncertain directionality of AR positioning is another issue. Under the static state applied to existing GPS, AR positioning nowadays can only tell the information of physical location without giving further specific directionality. Relying on such AR

applications unable to tell specific directionality, even though the constructing units of road excavation indeed grasp physical location, they are somehow incapable of preventing mis-digging and the lurking disastrous consequences. Therefore, with the cross-referencing between the measurement by national GPS positioning and the manual inspection of pipeline data/maps (e.g., the positioning error is acceptable only within 30 cm in X city) as shown in Figure 5, the ubiquitous hole-covers in great numbers could effectively help to point out the precise directionality of pipelines underground. As a suggestion, namely, the identifiable orientation drawn by the horizontal axis between two separated hole-covers is a supplement to the inaccuracy and the non-directionality of AR positioning in road excavation mentioned above.

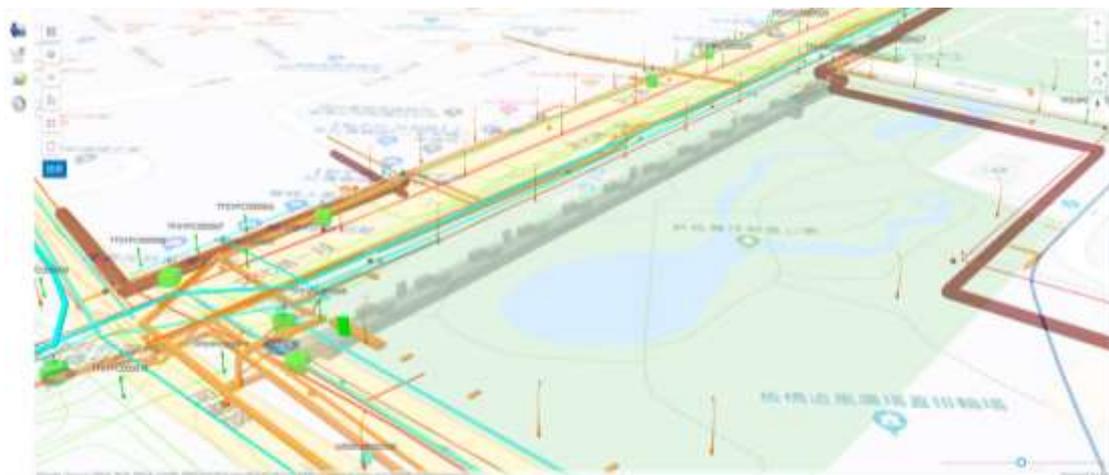
Simultaneous Localization and Mapping (SLAM) may improve the precision and try to answer the directionality question of AR positioning. The definition of SLAM is the user moves in space, locates his own position or posture based on the observed map features, and uses specific calculation techniques to achieve simultaneous positioning and map construction. For example, Google collected street view data and did the image processing to retrieve multiple feature points of architectures for drawing spatial maps. Therefore, when we use Google street view AR positioning, the images of a real environment are required to analyze, capture, and compare to the spatial maps made in advance. Accordingly, calculating relative angles and distances from the captured real scene image and GPS coordinates to the spatial maps could provide better precision and try to solve the directionality problem of AR positioning, as shown in Figure 6.



Source: Google maps app.

Figure 6: Google AR maps.

However, the street view and spatial maps mentioned above are owned by Google, which indicates another SLAM method should be taken to improve the precision and try to respond to the directionality question of AR positioning. In X city, public infrastructure pipeline databases are maintained by the following SOPs. Firstly, pipeline maps should be checked and corrected very carefully. For example, according to the engineering survey, pipeline owners fill the attributes of pipelines such as diameters, starting points, intermediate points, endpoints, and laying depths. Then the authorities concerned verify the correctness and the rationality of the pipeline information. Secondly, the pipeline maps and the related facilities are converted into RIM (Road Information Modeling), as shown in Figure 7. Different from BIM (Building Information Modeling), which focuses on the construction of 3D models for buildings or architectures, RIM is defined as 3D objects of roads and related facilities that provide management at all stages of the life cycle, including plan, design, construction, and maintenance.



Source: This study.

Figure 7: RIM.

Therefore, with the cross-referencing between the measurement by national GPS positioning and the manual inspection of pipeline data/maps (e.g., the positioning error is acceptable only within 30 cm in X city) as shown in Figure 8, the ubiquitous manhole or handhole covers (as shown in Figure 9) in great numbers could effectively help to point out the precise directionality of pipelines underground. As a suggestion, namely, the identifiable orientation drawn by the horizontal axis between two separated manhole-covers is a supplement to the inaccuracy and the non-directionality of AR positioning in road excavation mentioned above, as shown in Figure 10.



Source: This study.

Figure 8: Public infrastructure pipeline databases.



Source: This study.

Figure 9: Manhole and handhole covers.



Source: This study.

Figure 10: Combination of AR and public infrastructure pipeline databases.

### CONCLUSION

Among the compilation of the definitions and the evolutions of AR, VR, and MR, AR finds itself a position attached utmostly to the physical environment. Despite the fact that AR has been perceived by the authorities concerned in Taiwan, it is actually an unfolded application so far in official affairs. Based on its 3D visibility hence, AR is proposed applying to the engineering planning of road excavation, including preview, execution, and review. Conditioned to the context of road excavation in X city, the inaccuracy and the non-directionality of AR positioning can be fixed by cross-referencing the road excavation system and public infrastructure pipeline database.

The application of AR in the context of road excavation brings certain help, whether in the pre-excitation, the excavation, or the post-excitation phases. For example, in the pre-excitation phase, AR could be applied to demonstrate pipeline complexities and obstacles underground to evaluate the construction cost; during excavation, AR pipeline positioning in the actual environment can be used to avoid the mis-digging or tremendous disasters not entirely, at least partially. In the post-excitation phase, 3D pipeline maps generated by AR provide a comprehensive perspective of pipeline conflicts as the basis to validate the correctness and the rationality of the pipeline information.

To sum up, the complementarity between AR positioning and public infrastructure pipeline database embodied in the engineering planning of road excavation in X city, whose bountiful pipeline maps support 3D images firmly, is the main idea depicted by this research. The obsolete approach to governmental affairs, on the one hand, must be upgraded by considering and implementing the ever-changing technology. Other than AR, VR, or MR, that is, any adequate technology should be put into consideration for better governmental efficacy. On the other hand, an ideal model like the AR technology applied in road excavation is what the authorities concerned should try to figure out to ensure the maximum of public welfare. Hopefully, more official attention to the related technical applications in governmental affairs can be aroused by this research.

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## Customer Segmentation Using Real Transactional Data in E-Commerce Platform: A Case of Online Fashion Bags Shop

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### ABSTRACT

Customer segmentation has been widely used in different businesses and plays important rules in customer service. How to get a suitable segmentation based on the real transactional data to fully mining the hidden customer information in the massive data is still a challenge in current e-commerce platforms. This paper develops a customer segmentation model for online shops and uses the real data from a fashion bag store as a case. This paper firstly conducts a data preprocessing to select the main customer features, then it constructs a segmentation model based on the Fuzzy C-Means algorithm, and finally accomplishes a customer prediction model using a probabilistic neural network to estimate new customer's customer type. The results show that the customer samples are classified into three types, and the prediction accuracy is more than 90%. After that, this paper demonstrates the typical features of each type of customer and compares the new group features with the prior VIP groups. The ANOVA analysis test results show that the new groups have more significant differences than prior VIP groups, which means more effective segmentation results.

*Keywords:* customer segmentation, Fuzzy C-Means, e-commerce platform, neural network

### INTRODUCTION

Facing more complexity and competition in today's fast-moving e-commerce, retailers need to capture customer behavior and improve customer satisfaction. Customer segmentation plays an important rule since consumers' buying behavior is not homogenous. Customer segmentation is dividing all customers into distinct groups that share similar characteristics, such as demographics, interests, patterns, or locations (Zhou, Wei & Xu, 2021). Customer segmentation has been widely used in different businesses such as telecom companies (Alkhayrat, Aljnnidi & Aljoumaa, 2020) and the bank industry (Jouzani et al., 2020). It has a positive effect on e-commerce (Li, Deolalikar & Pradhan, 2015). For sellers in e-commerce platforms, customer segmentation helps them to analyze the change of customer behavior of buying and returning, improve the choice of supplied products and personalize after-sales service; For customers, customer segmentation fulfills customers' needs to be more accurately positioned and improves customers' satisfaction with providing better shopping experience; For e-commerce platform managers, customer segmentation system can improve the organization of customer information in the platform and implement the accurate of information services.

Customer segmentation results depend on the data source for feature selection and clustering method (Song et al., 2021). The most commonly used procedure to obtain the customer data consists of filling in questionnaires (Ortigosa, Carro & Quiroga, 2014) and asking the consumers (Rohm & Swaminathan, 2004). Traditional customer segmentation often identifies customers as different level VIPs (very important person). Lee and Lee (2020) tested the difference between regular customers and VIP customers of Internet Banking, and the results indicate that regular customers and VIP customers differently perceive service quality that is relevant to customer satisfaction. Magatef and Tomalieh (2015) pointed out after charging an upfront Fee for VIPs. The VIPs are relieved of inconveniences that could impede future purchases. However, it is not the most effective customer loyalty groups compare with other groups such as tier groups where customers extract long-time value. Both the questionnaire data and VIP segmentation approach often fail due to rapidly changing e-markets.

In e-commerce, fortunately, there are large real-time transaction databases containing customer data about demographics and buying or return information. On the premise of protecting customers' privacy, these databases can be used to segment the customer and benefit customer relationship management. As an example, retailers can find those people who like to return goods and take actions to improve their satisfaction and reduce customer returns (Cullinane & Cullinane, 2021), which has brought great economic losses to e-commerce platforms, commodity suppliers, logistics carriers, and consumers (Lysenko-Ryba & Zimon, 2021). For these massive datasets, machine learning algorithms, including the clustering method (Sivaguru & Punniyamoorthy, 2020) and neural networks, are appropriate tools to explore customer value effectively. Though many segmentations algorithm have been presented, their effectiveness depends on detailed data sources of customers. As an

example, the customers and their transaction data of a small online fashion clothing shop are very different from those of Amazon. So segmentation methods are needed to design for special online shops.

This paper constructs a customer segmentation model and a customer prediction model for an online fashion bag shop with a clustering algorithm and neural network technology. The real data from more than 15000 customers of the shop over one year are tested. This paper first standardizes customer data, sets and makes correlation analysis to select those main feature variables. After that, the Fuzzy C-Means clustering algorithm is utilized to cluster Customer features. Then probabilistic neural network algorithms are used to build the customer prediction model between customer features and customer types. The accuracy of this model is estimated by test samples. Then this paper employed ANOVA analysis to reveal that the new types have more significant differences than the prior groups based on the VIP system.

## RELATED WORKS

### Customer Segmentation

Customer segmentation will split the customer base into smaller groups using a variety of unique customer characteristics to help business people. Different feature data have been employed for use segmentation. A common model is based on three variables of RFM (Recency, Frequency, and Monetary), where Recency shows the time since the last customer purchase transaction, frequency indicates the number of purchase transactions in a time, while monetary shows the value of the purchase (Marisa et al., 2019). Christy and Umamakeswari developed a scoring method to evaluate scores of RFM. Some researchers try to develop an RFM model and add some parameters to these three parameters. Khajvand et al. (2011) proposed an extended RFM analysis method with one additional parameter, Count Item. The results of these approaches show that adding count Item as a new parameter to the RFM method makes no difference to clustering result when calculating the Customer Lifetime Value. Cheng and Chen (2009) derived an augmented RFM model, called the RFMTC model (RFM plus Time since first purchase and Churn probability), using the Bernoulli sequence in probability theory. Amine, Bouikhalene, and Lbibb (2015) considered the customer's relation length (L), named LRFM, where L is defined as the number of time periods (such as days) from the first purchase to the last purchase in the database to evaluate the customer's loyalty. In the ride-sharing market, Li et al. (2018) used the length of the membership (L) and replaced the original consumption amount (M) with the two indicators, such as the travel distance (M) and the average value of the discount coefficient (D) enjoyed by the customers in a certain period of time, established a reasonable customer value evaluation model called LRFMD. K-LRFMD to conduct the clustering analysis.

In fact, more online attribute data besides RFM parameters can also be employed for customer characters. Rohm and Swaminathan (2004) presented that online consumer behavior involves various stages of the consumer decision-making process, including introducing problems, information searches, evaluating, and results. In each stage, consumer behavior is greatly influenced by the development of digital technologies, social and cultural changes, and the impact of the closest people on their opinions. Rohm identified four types of online food buyers with different shopping behaviors: convenience shoppers, variety seekers, balanced buyers, and store-oriented shoppers, for example, the convenience of buyers is to save time on online shopping, but various searchers want to have something new when choosing a brand, product or store; this different behavior leads to different choices. In their Analysis, the most common attributes used are location, age, sex, income, lifestyle, and previous purchase behavior. Ortigosa et al. (2014) got the data from some Spanish-speaker customers on Facebook and assumed that customers with similar personalities would show common behavioral patterns when interacting through virtual social networks. They trained a classifier using different machine-learning techniques with the purpose of looking for interaction patterns that predict the customers' personality traits. Inspired by the context, in this research, we employ real online data, including demographic, purchasing data, and return data for segmentation.

### Clustering Techniques

There are two basic types of clustering methods, hierarchical and non-hierarchical. Hierarchical clustering is based on cluster analysis which builds a hierarchy of data points as they move into a cluster or out of it. Strategies for this algorithm generally fall into two categories: agglomerative and divisive. The main advantage of Hierarchical clustering is that the output is in the form of a hierarchy (dendrogram), which tells us exactly at which point the clusters merged or split. Hence it is easy to choose and decide the number of clusters that we wish to take by looking at the dendrogram. However, for a large number of observations, its computational speed is very low as compared to the nonhierarchical methods of clustering.

Another most commonly used algorithm is called k-means due to the fact that the letter k represents the number of clusters chosen. First, an initial set of means is defined, and then subsequent classification is based on their distances to the centers. Next, the clusters' mean is re-computed again, and then reclassification is done. This is repeated until cluster means don't change much between successive iterations. Kanavos et al. (2018) proposed a parallel K-Means algorithm based on MapReduce framework for Large Scale Product Recommendation of Supermarket Ware Based on Customer Behavior Analysis, and they utilize a supermarket database and an additional database from Amazon, both containing information about customers' purchases. Marisa et al. (2019) obtained Customer Lifetime Value (CLV) in two customer segments. Grouping uses the K-Means Clustering method based on the LRFM model. Ortigosa et al. (2014) used a two-stage method for clustering. In the first stage, the self-organizing maps method is used to determine the best number of clusters, and in the second stage, the k means the method is applied. Seven hundred thirty customers of the biggest online retailers specialized in electronics and home applications are segmented into nine clusters. However, Tripathi, Bhardwaj & Poovammal (2018) pointed out two major problems in cluster analysis. One is the difficulty to select the number k of clusters, this algorithm does not have the optimal

number of clusters, and another major downside is that it depends upon the initial cluster centers. Hassan, Shah, Othman, and Hassan, pointed that FCM is more superior to K means by producing balanced clusters with the random distribution manner. Kaile Zhou and Yang (2020) also compared the effect of cluster size distribution on k-means and fuzzy c-means (FCM) clustering. The results demonstrate that FCM has a stronger uniform effect than k-means clustering and is suitable for massive data. Therefore, this research uses the FCM algorithm for customer segmentation.

### Customer Prediction Model

Ortigosa et al. (2014) presented the techniques such as naïve Bayes, K-nearest neighbors, classification trees, and association rules were able to analyze the dataset and have similar performance, they chose classification trees and worked with the Weka data mining toolbox to analyze Facebook data and Predict customer personality.

Stachl et al. (2020) used both linear and nonlinear regression models (elastic net, random forest) to predict personality and examined the extent to which individuals' Big Five personality dimensions can be predicted on the basis of six different classes. They collected data from 624 volunteers over 30 consecutive days (25,347,089 logging events) and evaluated the models using a (nested) cross-validated approach. The results are similar to the customers' digital footprints from their smartphones.

Kanavos et al. (2018) implemented the Map-Reduce model to process the large datasets of a supermarket from Amazon using a distributed and parallel algorithm. They targeted classifying customers according to their consuming behavior and consequently recommended new products more likely to be purchased by them. Results showed that the proposed method predicts with high accuracy the purchases of the supermarket.

Gu et al. (2020) presented that probabilistic neural network (PNN) shows high efficiency when solving pattern recognition and prediction problem since the calculation results are universally reliable. Mohanty and Palo (2020) recommended the PNN model for children's emotion reorganization due to its accuracy level with the statistical features. Therefore, this research uses the PNN network to predict the unclassified customer.

### Statistics and Characteristics of Customer Groups

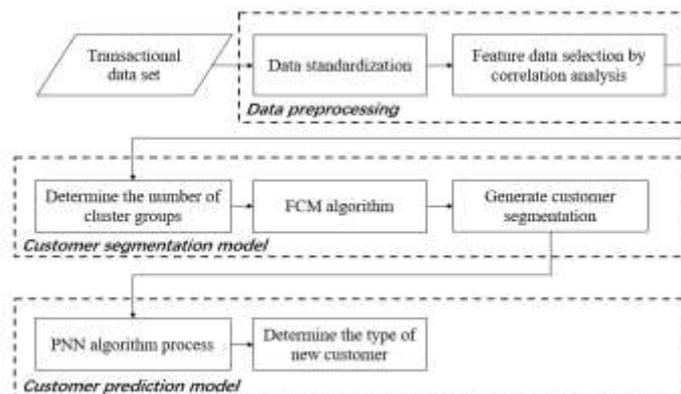
An obvious disadvantage of Neural Network algorithms is that there is a lack of interpretability of the results, i.e., they do not provide the weights and statistical importance of the input variables in the prediction, so in this paper, we try to show the statistical properties of the different groups.

Magatef and Tomalieh (2015) applied the ANOVA analysis on data collected for marketing segmentation and provided some inferences. The result indicated that some variables are insignificant at the confidence level while others are statistically significant as they have high probabilities. Rohm and Swaminathan (2004) employed univariate ANOVA and chi-square tests to identify the behaviors of different facebook customer clusters. They examined several variables (e.g., age, household size, per capita income, gender, and product type) that potentially influence retail shopping and online purchasing behavior of the clusters. The results revealed no differences in age, income, and household size across the four online shopping types. The results also indicated significant differences in purchase behavior across clusters for the following product classes: books and magazines software, etc.

For our data, the test clearly shows the data have unequal variances. So ANOVA based on Games-Howell in SPSS is used to compare all possible combinations of group differences since this method does not require the groups to have equal standard deviations.

## RESEARCH MODEL

This paper constructs a customer segmentation model and a customer prediction model with correlation analysis, clustering algorithm, and neural network technology. The data of online shopping and returns from customers of e-commerce platforms are used in the models to profile customers. The Customer segmentation model is constructed with Fuzzy C-Means clustering algorithm, while the customer prediction model is realized by the PNN network. A specific flow chart of the two models is shown in figure 1.



Source: This study.

Figure 1: The flow chart of the Customer segmentation model and user prediction model.

In this section, some key steps in the flow chart of the Customer segmentation models are described as follows.

### Data Preprocessing 1: Standardize Data Formats

The raw data/attributes of online customers used for customer segmentation models are classified into three formats, including numerical format, ordinal format, and categorical format (Jayarathna, Patra & Shipman, 2015). In order to weaken the impact of different dimensions better, each format of data is standardized by the corresponding method. For numerical format, this paper applies the Min-Max standardization method to standardize the data. For customer features of ordinal format, this study sorts the specific features into  $n$  grades according to certain rules, and then assign different sizes of value to features of the different customer according to the order, then use the equation (1) to standardize ordinal features, where  $x_i$  is the normalized value of an ordinal feature,  $i$  is the rank order of the ordinal feature value and  $n$  is the total number of the ordinal feature value formats.  $x_i = \frac{i}{n}$  (1)

For category format, this paper designs certain rules to sort the category data and then process the data according to the standardization method of ordinal features. Taking the attribute of customer's location city in the customer data set as an example, the data can be sort into six city levels according to the China city ranking 2020 released by the new first-tier city Research Institute, namely, first-tier city, second-tier city, third-tier city, fourth-tier city, fifth-tier city and not listed city. The cities where customers live are sorted according to the city level, and then the ordinal method is used for standardization.

### Data Preprocessing 2: Select Customer Feature Data by Correlation Analysis

The Pearson correlation coefficient and correlation matrix are utilized to study the correlation degree between the customer's raw transaction data and returns data (Abdulhafedh, 2021) and to select those feature variables having a high correlation with the customers' behavior of return, which is cared by the retailer as the customer segmentation features.

The correlation matrix  $R$  can be written as equation (2), where  $\rho_{ij}$  ( $i, j = 1, 2 \dots n$ ) is the correlation coefficient of attributes  $x_i$  and  $x_j$ .

$$R = \begin{bmatrix} \rho_{11} & \rho_{12} & \dots & \rho_{1n} \\ \rho_{21} & \rho_{22} & \dots & \rho_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \rho_{n1} & \rho_{n2} & \dots & \rho_{nn} \end{bmatrix} \quad (2)$$

The representative attributes with a high correlation coefficient in the correlation matrix are selected as the features in the customer segmentation and to construct the prediction model between customer types and customers' shopping behaviors.

### The Customer Segmentation Model

Customers can be classified into different types by attribute similarity calculation. In this paper, the FCM algorithm is used to cluster.

In the FCM algorithm, a membership degree  $u_{ij}$  between 0 and 1 is used to represent the similarity degree between the  $i$ -th cluster group and the  $j$ -th customer sample, which meets the following constraint condition:

$$\sum_{i=1}^c u_{ij} = 1, j = 1, \dots, n \quad (3)$$

A membership matrix  $U$  with the size of  $n \times c$  is composed of  $n$  customer samples and  $c$  clustering groups. The objective function of the FCM algorithm is shown in equation (4).

$$J(U, c_1, \dots, c_c) = \sum_{i=1}^c J_i = \sum_{i=2}^c \sum_j^n u_{ij}^m d_{ij}^2 \quad (4)$$

where  $c_i$  is the cluster center of the  $i$ -th cluster group,  $d_{ij}$  is the Euclidean distance between the cluster center of the  $i$ -th cluster group and the  $j$ -th customer feature sample.  $m$  is the membership factor, and the default value is 2. Therefore, by minimizing the objective function  $J$ , the best cluster numbers  $c$  and  $u$  for every sample and their group are obtained.

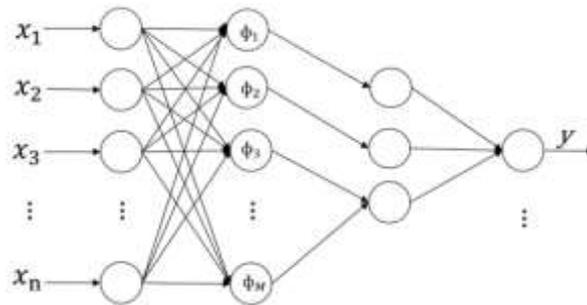
The effect of the clustering algorithm is closely related to the rationality of input parameters. However, the rationality of the selected cluster number  $c$  cannot be fully considered in manual selection. Therefore, we use partition coefficient  $V_{pc}$  and partition entropy  $V_{pe}$  to measure the clustering effect when the cluster number  $c$  value is different.

**The Customer Prediction Model**

After customer segmentation based on the features of purchase and return behavior, we can use a neural network to establish a nonlinear prediction model so that when unlabeled customers appear in the e-commerce platform stores, we can use the model to predict which types/groups of customer segmentation the unlabeled customer may be according to the features data recorded in the stores.

The prediction model based on Probabilistic Neural Network (PNN) is used in this paper. PNN is a neural network designed by the principle of statistics. It belongs to RBF neural network. It has considered both density function estimation and Bayesian decision theory. PNN has a simple structure, easy training process, and fast speed of obtaining results. It is very suitable for real-time processing data and has a wide range of applications (Satheesh & Nagaraj, 2021). It can achieve arbitrary nonlinear approximation.

In this paper, the PNN network structure is with four layers is employed. The customer samples are received by the input layer and then go through the mode layer and the summation layer. Finally, the classification results are output from the output layer. The network structure is shown in figure 2.



Source: This study.  
Figure 2: The structure of the PNN neural network.

The process of training and testing the PNN neural network algorithm is as follows:

Step 1: The features data of the customer samples which have been profiled are selected as the input variables  $x_i$ , and the corresponding clustering results  $y$  of these customer samples are used as the output variables.

Step 2: According to a certain proportion, the customer samples are classified into two categories: the training samples used to train the neural network structure and the test samples used to test the accuracy of the neural network. More details will be introduced in section 4.

**RESULT OF CUSTOMER SEGMENTATION AND PREDICTION**

**Collection and Analysis of Customer’s Data**

This research is in collaboration with a flagship store of women's fashion bags on the Taobao e-commerce platform, and the data comes from the store's background data server, however considering the interesting relationship, these data are processed with data masking techniques to obfuscate some sensitive data. Finally, we extract the transaction data of 15858 customers with return records in one year from the back-end database.

These raw transaction data attributes consist of (1) customer basic information, including customer’s name, customer’s member rank, customer’s location; (2) customer return information, including the number of orders returned, proportion of orders returned, amount of order returned; (3) customer purchase information, including buyer's payment payable, seller's actual payment, the total number of orders, buyer's actual payment amount, price of the purchased product, the delay time of payment, the delay time of receiving goods, the total number of product purchased, the average value of product category and product number in a single purchase, discount rate of orders, whether the customer leaves a product review, etc.

**Selection of Customer Features**

Firstly, the study standardizes the numerical attributes, ordinal attributes, and categorical attributes of the original customer information, transforms them into a data matrix, and calculates the correlation matrix as table 1.

Table 1: Correlation matrix table of customer attributes.

	Member rank	City level	Average value of buyer's payment payable	Maximum value of buyer's payment payable	Minimum value of buyer's payment payable	...	Delivery time	delay	discount rate of orders
Member rank	1.00	-0.01	0.02	0.04	0.00	...	0.00		0.01
City level	-0.01	1.00	0.02	0.03	-0.01	...	-0.01		0.01

Average value of buyer's payment payable	0.02	0.02	1.00	0.96	0.97	...	0.04	0.25
Maximum value of buyer's payment payable	0.04	0.03	0.96	1.00	0.86	...	0.03	0.28
Minimum value of buyer's payment payable	0.00	-0.01	0.97	0.86	1.00	...	0.04	0.21
⋮	⋮	⋮	⋮	⋮	⋮	...	⋮	⋮
Delivery delay time	0.00	-0.01	0.04	0.03	0.04	...	1.00	0.07
Discount rate of orders	0.01	0.01	0.25	0.28	0.21		0.07	1.00

Source: This study.

From the correlation matrix  $R$ , it can be observed that the correlation between the number of returns and the total number of orders is high, with a correlation coefficient of 0.60. In addition, the negative correlation between the return proportion and the cumulative consumption amount, the total number of transaction orders, and the number of successful transactions are high, with the correlation coefficients of -0.70, -0.41, -0.80, respectively. The positive correlation between the return proportion and the number of return orders is high, with a correlation coefficient of 0.45. The correlation between the return amount and the total number of transaction orders, as well as the correlation between the return amount and the number of return orders, is relatively high. The correlation coefficients are 0.51 and 0.79.

Considering the correlation coefficients and the representativity of customer features, the study selects 14 main feature variables to construct customer segmentation, including basic customer features, return features, and purchase features which have high correlations with return features ( e.g., customer's member level, customer's location, number of order returned, the proportion of order returned, cumulative return amount, order payment amount, cumulative consumption amount, price of the product purchased, a quantity of purchased product, type of purchased product, count of consumption order, whether to participate in pre-sale, payment delay time, Proportion of order discounts, etc. ).

### Result of the Customer Segmentations Model

Using Bezdek's clustering validity function-partition coefficient and partition entropy (Tekin, Kaya & Cebi, 2021), we can know that 3 is the best number of cluster groups.

Then FCM algorithm is used to cluster the customer return features. The clustering result shows that in 15858 customer data samples, the number of customer samples contained in type 1 ( $C_1$ ), type 2 ( $C_2$ ), type 3 ( $C_3$ ) is 7922, 4840, 3096 respectively, accounting for 50%, 30%, 20% of the total number of samples.

In order to compare the feature variables of different cluster groups, the average values of customer basic feature variables, return feature variables, and purchase variables of customer samples in each cluster group are listed in table 2.

Table 2: The result of customer sample classification.

Clustering group $c_i$		Type1	Type2	Type3		
Number of samples		7922	4840	3096		
Customer features	Customer basic features	Member rank	1.04	1.06	1.04	
		City level	3.30	3.36	3.33	
	Customer return features	Count of return orders	1.00	1.09	2.34	
		Proportion of return orders	0.50	0.29	0.59	
		Cumulative return amount	126.83	144.19	304.36	
	Customer purchase features	Features of consumption amount	Order payment amount/yuan	124.24	129.24	129.35
			Accumulated consumption amount / yuan	124.98	350.05	218.06
			Price of the product purchased / yuan	112.55	110.49	110.77
		Features of consumer products	Product number in a single purchase	1.13	1.26	1.20
			Product kind in a single purchase	1.12	1.20	1.19
		Features of consumption frequency	Total number of consumption order	2.01	3.93	4.08
		Features of pay in advance	Rate of participation in the pre-sale	0.14	0.15	0.16
		Features of paying habit	Payment delay time	51.19	69.53	76.43

		Features of price-sensitive	Proportion of order discounts	0.03	0.01	0.01
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Source: This study.

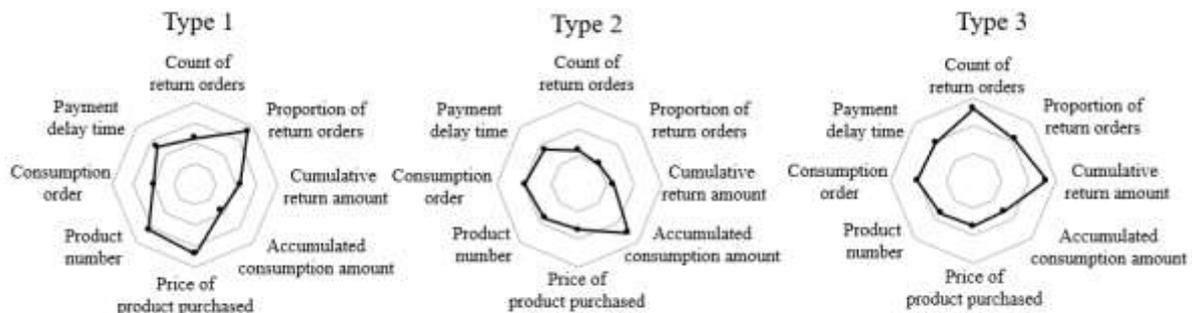
### Result of the Customer Prediction Model

After building the customer segmentation based on customer features data, we use a neural network to build a nonlinear prediction model between customer features and customer types and train the neural network. The prediction model based on the purchase features of profiled customers can be used to predict the type of new customers. In the experiment, these features, including cumulative consumption amount, the total number of consumption orders, product number in a single purchase, product kind in a single purchase, are selected as input variables. Customer type is used as an output variable to construct the probabilistic neural network.

In the experiment, the group of return feature data and the group of purchase feature data contain 15000 profiled customers, respectively. Among 15000 customer samples, 90% of customer samples are used as training samples, and 10% of customer samples are used as test samples. The correctness of the trained PNN will be tested with test samples. The test results of the neural network show that the prediction accuracy based on purchase features is more than 90%.

### DIFFERENCE ANALYSIS AMONG THREE CUSTOMER GROUPS

According to the Customer segmentation results in table 2, the main features of three types of customers are analyzed and discussed in this section. In this paper, these three types of customers are defined as impulsive customers, economic customers, and cautious customers.



Source: This study.

Figure 3: Typical features of three customer types.

#### Customer Type 1: Impulsive Customer

In this paper, type 1 customers are defined as impulsive customers who have the minimum payment delay time among the three types; the reason could be they do not want to spend time shopping. The customer samples of type 1 account for 50% of the total samples. It can be seen from the radar chart of eight dimensions in figure 3 that its typical features are fewer consumption orders, fewer return orders, lower cumulative consumption amount, and cumulative return amount than the other two types, but the proportion of return orders is higher, the average price of purchased products is higher, the quantity of purchased products is less, and the payment delay time is less than other two customer types.

According to their fewer consumption orders, fewer return orders, lower cumulative consumption amount, and cumulative return amount, these kinds of customers are referred to have low loyalty to the stores. According to the small number of products in a single purchase, customers of type 1 are referred to only purchase the target products and are not inclined to store goods. According to their short payment delay time, impulsive customers are easy to buy products impulsively, but they are also easier to regret after the purchase, so the probability of return behavior is higher than the other two types.

#### Customer Type 2: Economical Customer

Type 2 customers are defined as an economical customer because they have the minimum average price of purchased products among the three types. They account for 30% of the total samples. Its typical features are the medium number of consumption orders, fewer number of return orders, a higher amount of cumulative consumption, and the medium cumulative return amount compared with the other two customer types. The proportion of return orders is low, the average price of purchased goods is low, the quantity of products in a single purchase is large, the payment delay time is medium, and the payment enthusiasm is medium.

The customer of type 2 is defined as the economical customer. Considering their fewer number of return orders, the lower average price of purchased products, and a large number of products in a single purchase, economic customers, are referred to think a lot about whether the price is affordable or not when they choose products. They are more sensitive to the price of

products and more likely to buy products at one time to get preferential discounts. Besides, taking their medium number of consumption orders into consideration, this kind of customer has a certain degree of loyalty after finding a shop with appropriate prices.

### Customer Type 3 : Cautious Customer

Customers of type 3 can be defined as cautious customers. According to their high payment delay time, cautious customers are more cautious when buying goods. The typical features of customer type 3 are the relatively large number of consumption orders and return orders, high cumulative return amount, the proportion of return orders, and the payment delay time compared with other customer types.

They don't like to make a hasty decision to buy products. They tend to consider carefully before the payment. Customers of type 3 are referred to require products of high quality, so the proportion of return orders is high. The loyalty of cautious customers is high, and they tend to choose familiar stores for repeated purchase, so the number of consumption orders is large, and the cumulative return amount is high.

### Customer Cluster Compare with VIP Groups by ANOVA

There are many statistical tests that are normally used to perform the clustering process. In this paper, ANOVA is employed for various analyses and data processing, including clustering and data mining. The ANOVA is invariably used in comparing more than one means or centroids. In its simplest form, ANOVA provides a statistical test of whether or not the means or centroids of several groups are all equal or not.

We first compare the variable means of traditional clusters, i.e., NON VIP, VIP1, and VIP2, and then we show the comparison among the means of new clusters, i.e., type1, type2, and type3. As shown in Table.3, 4 chosen variables are Consumption order, Accumulated consumption amount, Proportion of return orders, and Payment delay time(s). The reason is that these variables have similar character as RFM. The Payment delay time is a time character instead of the recency (how recently a customer has made a purchase and take the place of R. Accumulated consumption amount in one year is the frequency (how often a customer makes a purchase), and Accumulated consumption amount shows how much a customer spends (monetary). The proportion of return orders is an additional variable to represent how much loss they bring to retailers.

Table 3: One-Way ANOVA ( Analysis of Variance ) of Existing VIPs.

	(I) Existing customer groups	(J) Existing customer groups	Mean Difference (I-J)	Std Error	Sig
Consumption order	non VIP (mean=2.99)	VIP1 (mean=3.02)	-0.032	0.069	0.890
		VIP2 (mean=3.51)	-0.514*	0.123	0.000
Accumulated consumption amount	NON VIP(mean=210.64340)	VIP1 (mean=220.852)	-10.209	8.263	0.433
		VIP2 (mean=280.311)	-69.667*	16.805	0.000
Proportion of return orders	NON VIP(mean=0.454846)	VIP1(mean=0.449)	0.005	0.006	0.728
		VIP2(mean=0.422)	0.032*	0.110	0.011
Payment delay time(s)	NON VIP(mean=61.9223)	VIP1(mean=53.253)	8.668	12.066	0.753
		VIP2(mean=63.271)	-1.349	15.872	0.996

\*The mean difference is significant at the 0.05 level

Source: This study.

Most of the comparisons are not significant. For example, when considering the variable Consumption order, the results of Comparison 1 (Non-Vip vs. VIP1) is not significant ( $p = 0.890 > 0.05$ ), and for Comparison 2 (non VIP vs. VIP2), the difference is significant ( $p = 0.00 < 0.05$ ), so the Univariate ANOVA results revealed no differences in Consumption order, Accumulated consumption amount, Proportion of return orders and Payment delay time between the existing shopping types (Non-VIP and VIP1). This suggests a homogeneous online shopping sample with respect to demographics. For Non-VIP and VIP2, the results show a significant difference in Consumption order, Accumulated consumption amount, and Proportion of return orders. Their mean differences are -0.514, -69.667, and 0.032. However, these differences are less than the differences between the new types as 2.077, 104.933, and -0.075 (in the latter table). This demonstrates that the degree of differentiation is still not high enough in existing clusters. The one-way ANOVA statistics applied to new groups are listed in Table 4. It was very clear from that statistic test that four chosen variables were significantly different across the three final clusters obtained by k-means clustering, as shown.

Table 4: One-Way ANOVA ( Analysis of Variance ) of new Groups.

	(I)proposed used groups	(J)proposed used groups	Mean Difference (I-J)	Std Error	Sig
Consumption order	TYPE1 (mean=2.010)	TYPe2 (mean=3.920)	-1.906*	0.018	0.000
		Type3 (mean=4.090)	-2.077*	0.023	0.000
Accumulated consumption amount	TYPE1 (mean=124.878356)	TYPE2(mean=344.543)	-219.664*	2.261	0.000
		TYPE3(mean=229.781)	-104.903*	2.635	0.000
Proportion of return orders	TYPE1(mean=0.499)	TYPE2(mean=0.297)	-0.202*	0.001	0.000
		TYPE3(mean=0.574)	-0.075*	0.002	0.000
Payment delay	TYPE1(mean=51.198)	TYPE2(mean=68.589)	-17.390*	6.802	0.029

time(s)		TYPE3(mean=77.648)	-26.449*	5.863	0.000
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\*The mean difference is significant at the 0.05 level

Source: This study.

### CONCLUSIONS AND IMPLICATIONS

Based on the customer data related to return features in e-commerce platform stores, this paper constructs a customer segmentation model and a customer prediction model between customer features and customer types. In the experiment, the customer segmentation classifies customer samples into three types, including impulsive customer, economical customer, and cautious customer. These two models can also be promoted to other products selling in the online stores to realize customer type segmentation quickly and well, so as to analyze the purchase habits and preferences of store customers. They also provide some basis for e-commerce platform stores to make differentiated sales service and reduce the high return rate.

However, there are still some limitations in the customer segmentation models designed in this paper. Follow-up work can be further studied from the following aspects: first, the algorithm used in the models still has its own defects. FCM algorithm needs to determine the number of clustering groups in advance, so it is difficult to apply to dynamic data. New algorithms can be used to improve the clustering result in the future. Secondly, the accuracy of the PNN neural network algorithm in the customer prediction model may not be stable in different data environments. Therefore, it is necessary to carry out more experiments to test the accuracy of different neural network algorithms in different environments. Finally, it is very important to combine the theoretical models with e-commerce practice. Only in this way can the theoretical method really help the actual development of the e-commerce platform.

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## Customer-centered and Technology-Enabled Homecare Service: Opportunities for Value Creation

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### ABSTRACT

In the advancement of society, the ability to provide quality healthcare has been increased, and the use of smart technology in the healthcare environment has been widely seen. The study uses in-depth interviews and field observation methods to collect data, aiming at understanding the perspectives and needs towards technology-enabled services. In addition, according to the results of the interviews, the user journey maps for each of the three technological solutions (smart pillbox, smart mattress, wearable device) we proposed have been drawn, and the pain points, touchpoints as well as opportunities of each role have been discussed and summarized. Lastly, the blueprint of the entire home care service has been depicted, which we expected to provide a reference for home care service providers for applying smart technologies to their homecare service models and create new value from managing their operations.

*Keywords:* Home care, user journey map, service blueprint, pain point, service process improvement.

### INTRODUCTION

With the progress of society and the rapid development of medical technology, the proportion of the world's elderly population has risen dramatically. The aging society has become an important global issue. It not only changes the population structure but also affects the overall quality of medical services. In Taiwan, according to the estimation of the National Development Council, Taiwan will become a super-aged society by 2026, where at least 20 percent of the population is 65 or older (National Development Council [NDC], 2018). This might lead to an increase in health costs and social problems for personal care since elderly people are often faced with some chronic diseases such as diabetes, high blood pressure, or dementia. A report made by the Ministry of Health and Welfare (Taiwan) indicates that the number of people who need long-term care will increase from 557,000 in 2017 to more than 770,000 in 2026, and the proportion of the elderly has been increasing year by year (Ministry of Health and Welfare [MHW], 2016). Besides, due to Taiwan's declining birthrate, the old-age dependency ratio will increase to about 30 percent by 2026. Nursing manpower and medical care resources might not be able to meet the huge demand in the future. Therefore, it is urgent to reform the long-term care system in Taiwan.

Previous studies have shown that many elderly people are unwilling to live in care institutions but prefer to live in a familiar environment with personal privacy and a sense of belonging (Wang *et al.*, 2019). This shows no difference in Taiwan. From a survey of the living conditions of the elderly over the years, more than 60 percent of the elderly expressed that they do not want to live in a care institution. It can be seen that aging in place is not only an international trend but also more conform to the expectations and wishes of most elderly people. However, they sometimes cannot get immediate care when facing illness, and when an emergency occurs, they often delay seeking help or cannot obtain effective treatment. For these reasons, how to implement a high-quality and efficient long-term home care system to cope with the rapidly aging society has become a top priority for Taiwan.

Technology is a key instrument for a new concept of home care. With the development of various smart technologies, like IoT devices, sensors, artificial intelligence, how to apply them to the health care environment has been widely regarded. Countries across the world are also actively introducing smart technologies into the field of long-term care, hoping to make the elderly enjoy their old age more humanely and healthily (Haslwanter *et al.*, 2018). Existing research on technology-enabled home care services mainly focused on the detection of physiological status and the study of home-based medical devices. Apart from the discomfort manifested by physiological signals, there are other problems plaguing the elderly such as the caregiver's service level and care-receiver's psychological level, and so on.

Therefore, through semi-structured interviews, field observation, and the use of user journey mapping, this study aims at exploring the potential needs and pain points in long-term home care services, finding out what technology can be applied, and

understanding the elderly's attitudes towards technology-enabled services. A technical solution is then presented and drawn into a service blueprint according to these pain-point needs. We expected to provide a reference for home care service providers for applying smart technologies to their homecare service models and create new value from managing their operations.

## LITERATURE REVIEW

### Long-Term Home Care Services for The Elderly in Taiwan

According to Kane & Kane (1987), long-term care (LTC) was defined as providing health, personal care, and social services over a sustained period of time to people with congenital or acquired disabilities. Based on the concepts of long-term care, "home care" is one of the approaches to support "aging in place" since many older adults wish to live in their own familiar environment as long as possible. The benefits of home care are that the care is given in the comfort of the elderly's home, and it allows more freedom and independence. Furthermore, home care could reduce pressure on family members, who have always been the main provider of long-term care in Taiwan. (Liu et al. 2014; World Health Organization [WHO], 2015).

In Taiwan, long-term home care services can be mainly divided into two categories, which are "home care service" and "home health care services" (Chiu, 2016). Home care service offers non-clinical help, such as providing companionship and assistance with activities of daily living (ADL). For example, services such as bathing and toileting, taking medicine, meal preparation, getting in and off the bed, back-patting, dressing, and so on. Compared with home care, home health care service focuses more on providing professional medical assistance. Home health care service is usually ordered for elderly adults who require assistance with recent injuries, who are sick in bed, or who have been diagnosed with a chronic condition, like diabetes or other diseases. Medical services include the following: Wound care, rehabilitation, monitoring of health status, health education, etc. (MHW, 2016).

In order to use the home care service, people first have to apply to the care management center of each county or city in Taiwan. Based on the physiological, psychological, economic, and social support status of the elderly, and the individually caring program will be planned and tailored to their needs. When the application is approved, well-trained caregivers recruited by social welfare organizations will then be assigned to provide various services to the elderly with disabilities or chronic illness in their home regularly (Liao *et al.*, 2009).

### Aging Society and the Role of Smart Technologies in Home Care Service

With the burgeoning elderly demographic in Taiwan, the need for life support and health care is growing rapidly. However, under the trend of declining birth rate, the number of middle-aged people caring for elderly patients is increasing, which causes a heavy burden. Consequently, it is no longer possible to simply think about increasing caring manpower or medical resources to satisfy the needs. In order to decrease the burden of manpower and increase the care service quality, smart technologies have been increasingly developed and used in healthcare in recent years (Huang *et al.*, 2019).

Smart technologies were used for gathering and monitoring patient data, remote diagnosis, and treatment, providing a more convenient and efficient tool for caregivers. For example, elderly people with mobility difficulties often lie in bed, which becomes the most accident-prone area in a home care environment. Smart mattress can monitor the elderly's in-bed posture by using pressure sensors, and if the elderly tries to leave the bed themselves or are in the same posture too long, the smart mattress will remind the caregivers immediately in order to prevent falling accident or bedsore (Hong, 2018; Li & Xu, 2020). Besides, elderly people often suffer from poor compliance with medication, such as taking the wrong medicine, forgetting to take medicine due to illiteracy, or hypomnesia (Roy *et al.*, 2017). These situations will affect the therapeutic effect or even cause physical discomfort. The smart pillbox was designed to assist elderly people, reminding them to take the right dose of medicine at the right time and track their medication (Solanki & Zope, 2018). A wearable device is also a well-discussed technology in the health care field, and it can collect care receiver's physiological indicators, such as heartbeat, blood oxygen, blood pressure, temperature, blood sugar, or stress status, and can also be used to track the location of the elderly or emergency call (Wang *et al.*, 2017). Overall, these technologies are aimed at reducing the burden on caregivers, improving the quality of life of the elderly, and maximizing the effectiveness of the input of care resources.

Using smart technologies to cope with the health problems of an aging society might seem straightforward (Malwade *et al.*, 2018). Much research on smart technologies used in healthcare has mainly focused on technology adoption (Pal *et al.*, 2018) or the development of the function of the technology devices. However, the implementation of the technology becomes complicated due to user experience. Still, there is a lack of evidence concerning users' practical experience based on the journey mapping method. To know whether these technologies meet the needs of the elderly using home care services in Taiwan, it must be understood through the user's actual experience and opinion. Consequently, this study utilized user journey maps to investigate the elderly's user behavior and their acceptance of the technologies.

## RESEARCH METHODOLOGY

### Research Methods

The whole research can be divided into two stages. Firstly, we try to explore the potential needs and pain points in current long-term home care services and find out what technology can be applied. Based on the literature review and analysis, we first understand the development and current situation of home care in Taiwan. Then, through semi-structured interviews and field observation, the elderly's needs and pain points are described and analyzed. We then put forward some suggestions on introducing smart technologies in-home care services. Secondly, in order to understand the elderly and caregivers' attitudes toward the technology-enabled services, we conducted an interview based on grounded theory (Glaser & Strauss, 1967) to find out the direction of improving and strengthening the proposed technological home care service. Then, the pain points, contact points, opportunities, and solutions are analyzed with the user journey map and service blueprint to optimize the technological home care process.

### Research Subjects

In the first stage of the research, we select four frail elders who are cared for at home. They are the groups who have not reached the level of long-term care but need to be cared for due to factors such as aging or frailty. Therefore, we are better able to obtain detailed information from them through interviews.

In the second stage of the research, in order to understand the elderly and caregiver's attitudes toward technology-enabled services, We conducted in-depth interviews with 4 care receivers (code P) and their 4 caregivers (code C). All the care receivers who participated in the interview were over 65 years old who needed care. One interviewee had a face-to-face interview at home, and the other three had the interview online because of the severe epidemic. Besides, the caregivers involved in the interview are of a wider range of ages, ranging from young adults to old people (30 to 70 years old). One interviewee had a face-to-face interview in his office, while the other three were interviewed online. Detailed information of the interviewees is shown in Table 1.

Table 1: Interviewees' information of the second state of the research

Interviewee ID	Gender	Age	Symptoms	Pain Points	Technology Application
P1	Male	82	<ul style="list-style-type: none"> <li>⑩ Cancer</li> <li>⑩ Foot surgery</li> <li>⑩ Mobility impaired</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Light sleep</li> <li>⑩ Inconvenient getting in and out of bed</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> <li>⑩ Smart mattress</li> <li>⑩ IoT device</li> </ul>
P2	Male	71	<ul style="list-style-type: none"> <li>⑩ Stroke</li> <li>⑩ High blood pressure</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Mobility impaired</li> <li>⑩ Forgot to take medicine</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> <li>⑩ Smart mattress</li> </ul>
P3	Female	68	<ul style="list-style-type: none"> <li>⑩ Cancer</li> <li>⑩ Abdominal surgery</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Forget to take medicine</li> <li>⑩ Depraved appetite</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> </ul>
P4	Male	88	<ul style="list-style-type: none"> <li>⑩ Macular Degeneration</li> <li>⑩ Hard of hearing</li> <li>⑩ Alzheimer's disease (mild case)</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Get lost easily</li> <li>⑩ Can barely see things, need others guidance</li> <li>⑩ Forgot to take medicine</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> <li>⑩ IoT device</li> </ul>
C1	Male	46	-	<ul style="list-style-type: none"> <li>⑩ Patient with low mobility</li> <li>⑩ Patient often forgot to take medicine</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> <li>⑩ Smart mattress</li> </ul>
C2	Male	39	-	<ul style="list-style-type: none"> <li>⑩ Patient often forget to take medicine</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> </ul>
C3	Male	44	-	<ul style="list-style-type: none"> <li>⑩ Don't know what medicine the patient should take after the shift</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> </ul>
C4	Female	70	-	<ul style="list-style-type: none"> <li>⑩ Afraid of the patient getting lost.</li> <li>⑩ Afraid of repeated administration of a drug</li> </ul>	<ul style="list-style-type: none"> <li>⑩ Smart pill box</li> <li>⑩ IoT device</li> </ul>

## Research Process

As the research method mentioned above, we conducted two semi-structured interviews, which we will continue to discuss in Depth according to the respondents' answers. Before the interviews, we first introduce and explain the research purpose to the caregivers and the care receivers, asking if they can accept their answers to be taped for later research, and promise these will only be used for academic research so that the interviewees can be psychologically prepared for the interview. Besides, instead of forcibly visiting one by one according to the questionnaire content, the interviewees can naturally continue the topic and answer the true thoughts and feelings.

In the first interview, we inquired deeply about the pain points and the needs while the care receivers are receiving the home care service. At the same time, we observe and record the interaction between the caregiver and care receiver during the interview and ask how they feel. In the second interview, we ask them the functional requirements of the technological solutions that we proposed after the first interview, as well as the degree to which difficulties are solved under the condition of applying technological solutions, so as to know their satisfaction toward the technology-enabled home care services.

## RESULTS AND DISCUSSIONS

### Pain Points and Technological Solutions

Based on the answers and observation during the first state of the interview, we analyzed the care receivers' feelings and needs when they are receiving the home care service and carried out three pain points. Firstly, the elderly are worried about being scolded due to not taking medicine on time. The caregiver is also worried about the disease being ignored by the elderly, so someone needs to remind or assist when it is time to take medicine. Secondly, during the non-caregiver assistance period, when the elderly encounter sudden pain or illness caused by the injury or disease, they will often feel frustrated and is worried whether if it is a complication or not. Therefore, it is necessary to monitor and record the physiological state of the body throughout the day and be able to detect emergency situations and call for assistance or rescue immediately. Lastly, to most of the interviewees, the third pain point is the difficulty in getting in and off the bed, and it is painful due to the pressure on the wound when turning over during sleep, which makes them have a poor quality of sleep. Hence, a deformable mattress is needed, which is convenient for the elderly to get in and get off the bed. It can also be used for rehabilitation during home care and detect sleep quality, posture in bed or turnover, etc.

According to the needs and pain points above, the technological solution is proposed. The solution to the first pain point is the smart pill box, which helps family members or caregivers remind the elderly to take medicine. Moreover, the solution of the second pain point is the wearable physiological monitoring device and health cloud, which monitors the health status of the care receiver around the clock, notifies family members or caregivers in case of emergency, and uses health cloud to record health data, location, historical activities, and other information. Lastly, the solution of the third pain point is the smart mattress which provides a deformation function to make it easy for patients to get in and out of bed and for rehabilitation.

### Care Receivers' Attitude and Opportunities

Based on the technological solutions mentioned above, we conducted a second interview to find out the care receivers' and caregivers' attitudes toward these technological solutions. Besides, with the help of the user journey map, we try to have an in-depth understanding of the care receivers' mood and pain points when using these technologies and the opportunities to it.

#### (1) Opportunity 1 – A wearable device

According to the caregivers and care receivers interviewed, the functions that wearable devices should have been classified into two major features, the first one is the positioning system for monitoring the location of the care receivers and SOS emergency call function, and the second one is sleep monitoring and personal health data collection. Figure 1 below shows the care receiver's user journey map of the wearable device. We find out that due to the incomprehension of smart technology, care receivers have a lower mood for the need to purchase wearable devices, and they are more likely to feel frustrated and irritable when they have difficulties in using the product. But as soon as they realize that caregivers and themselves can monitor their health status constantly and they don't need to worry about getting lost, their mood goes up accordingly.

#### (2) Opportunity 2 – Smart mattress

According to the caregivers and care receivers interviewed, the functions that smart mattresses should have been classified into two major features, the first one is to help the care receivers get in and off the bed more easily, and the second one is to show the long-term compressed parts of the care receivers and remind family members to turn over and pat their backs. Figure 2 below shows the care receiver's user journey map of the smart mattress. We find out that the care receivers first think that the smart mattress is too expensive and feel that the product is unnecessary. After buying and using the product, they feel frustrated at the beginning because they don't know how to use it, and the data recorded shows that himself or herself has poor sleeping quality. However, as the lifting function and the recorded data really help and makes them live more comfortably, their mood goes up accordingly.

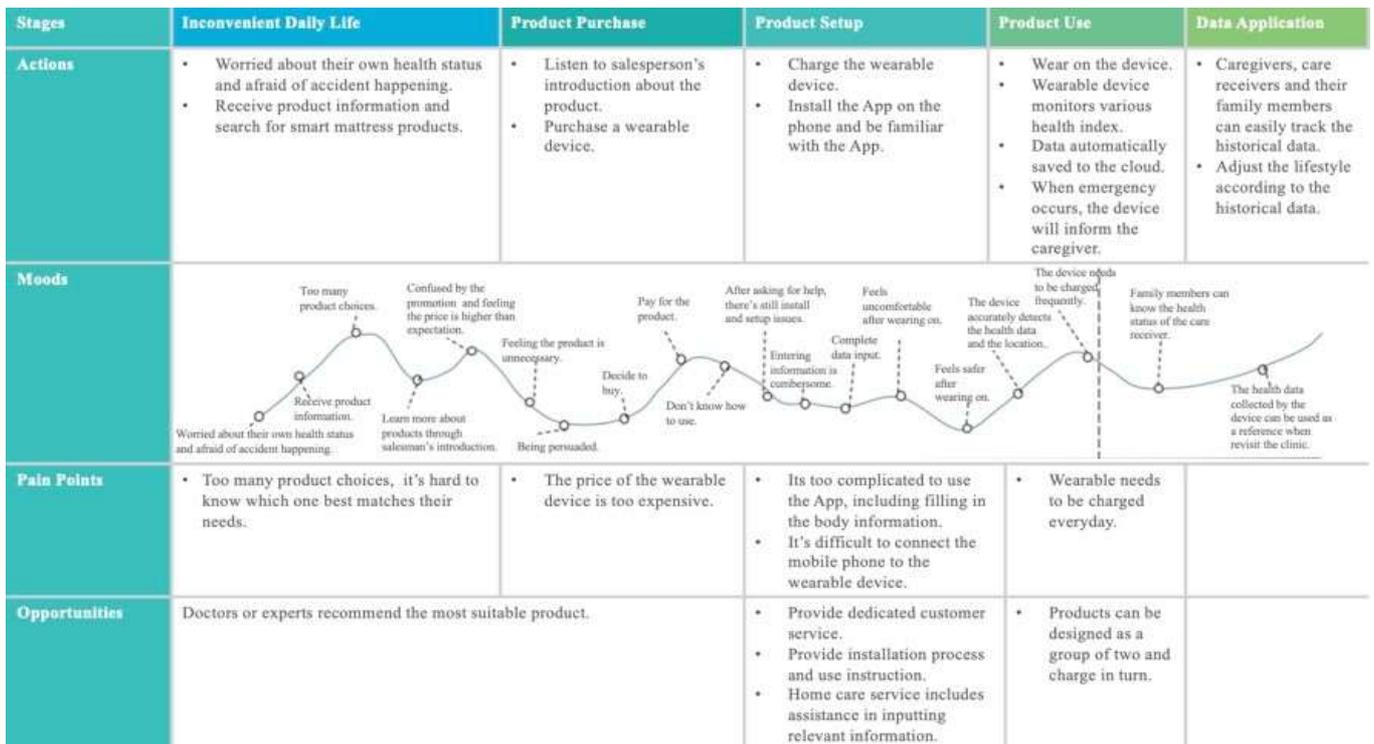


Figure 1: Wearable Device User Journey Map

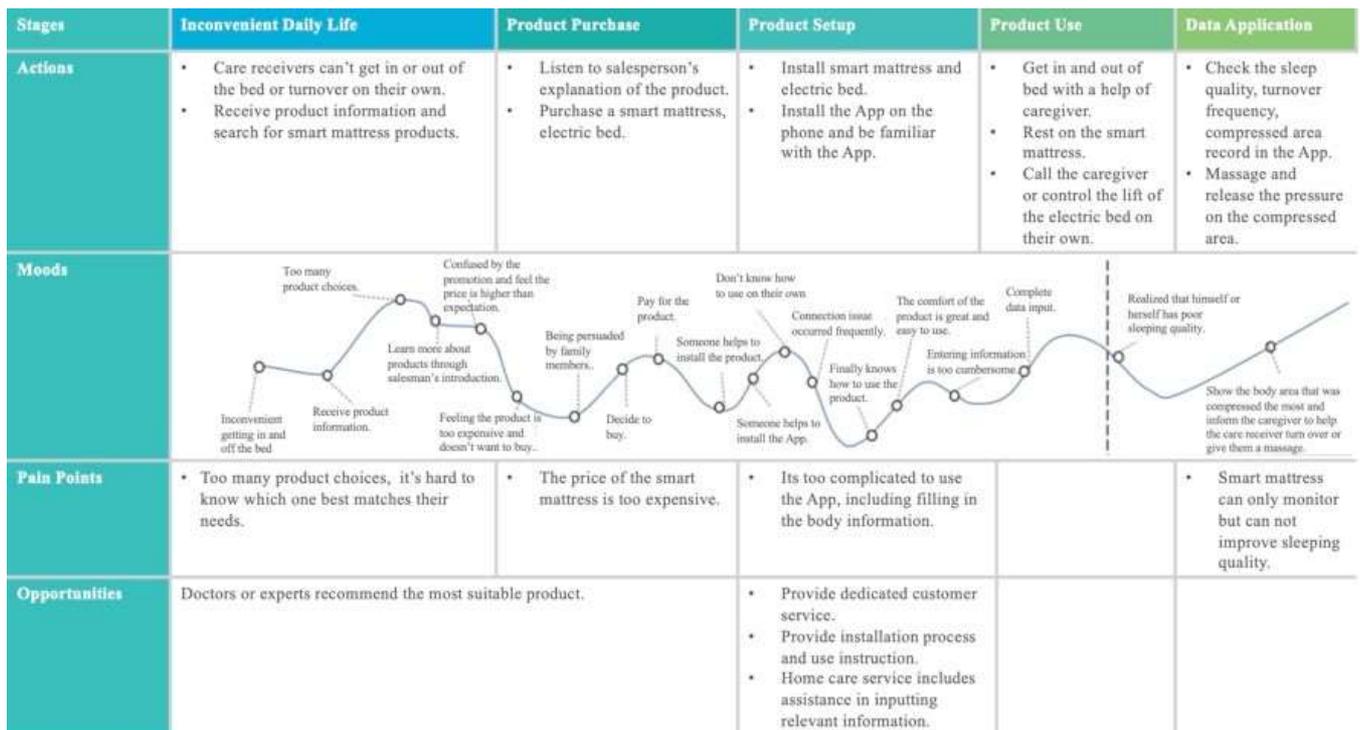


Figure 2: Smart Mattress User Journey Map

Stages	Inconvenient Daily Life	Product Purchase	Product Setup	Product Use	Data Application
Actions	<ul style="list-style-type: none"> <li>Patient often forget to take medicine, family members don't know how the drugs were used.</li> <li>Receive product information and search for smart pill box products.</li> </ul>	<ul style="list-style-type: none"> <li>Listen to salesperson's explanation of the product.</li> <li>Purchase a smart pill box that meets their requirements</li> </ul>	<ul style="list-style-type: none"> <li>Install the APP on the phone and connect it to the pillbox.</li> <li>Fill in personal data and be familiar with the app.</li> </ul>	<ul style="list-style-type: none"> <li>Put the medicine into the pill box according to the dosage.</li> <li>Take medicine when the pill box sends the alert.</li> </ul>	<ul style="list-style-type: none"> <li>Caregivers, care receivers and their family members can easily track the historical data.</li> </ul>
Moods					
Pain Points	<ul style="list-style-type: none"> <li>Too many product choices, it's hard to know which one best matches their needs.</li> </ul>	<ul style="list-style-type: none"> <li>The price of the smart pill box is too expensive.</li> </ul>	<ul style="list-style-type: none"> <li>Its too complicated to use the APP, including filling in the body and medication information.</li> <li>It's difficult to connect the mobile phone to the smart pill box.</li> </ul>	<ul style="list-style-type: none"> <li>The pill box's drawer is too small to pack a large dose.</li> </ul>	
Opportunities	Doctors or experts recommend the most suitable product.		<ul style="list-style-type: none"> <li>Provide dedicated customer service.</li> <li>Provide installation process and use instruction.</li> </ul>		

Figure 3: Smart Pill Box User Journey Map

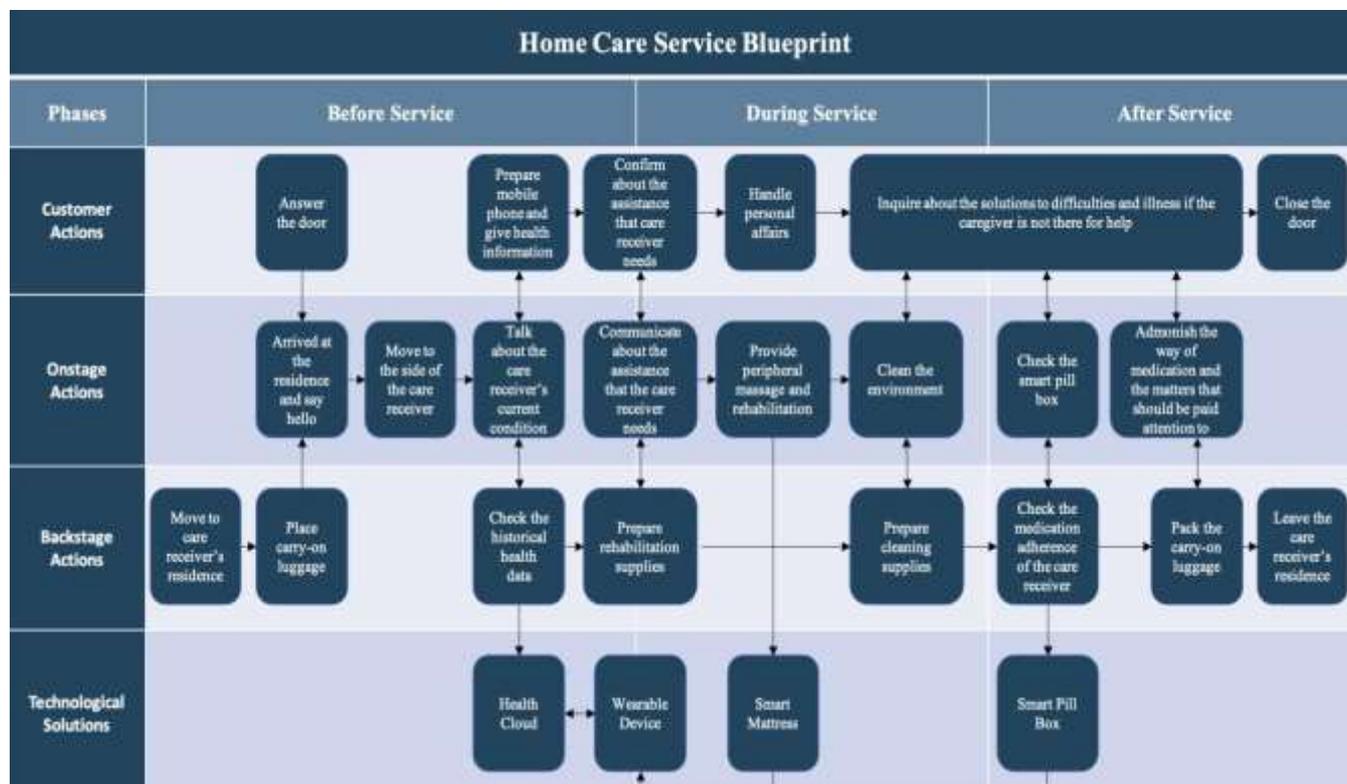


Figure 4: Technology-enabled home care service blueprint

### (3) Opportunity 3 – Smart pill box

According to the caregivers and care receivers interviewed, the functions that the smart pill box should have been classified into two major features. The first one is to remind them to take medicine at the right time with the right number of pills. The second one is to notify the caregivers through the mobile application if the care receivers forgot to take medicine. Figure 3 below shows the care receiver's user journey map of the smart pill box. We find out that due to the incomprehension of smart technology, care receivers have a lower mood for the need to purchase smart pill boxes. Besides, they also feel frustrated because of the difficult and cumbersome steps of loading the medicine into the pill box. However, after confirming that the pill box will remind them to take the medicine on time and they don't need to worry about being scolded because of forgetting to take medicine, their mood rises accordingly.

### Service Blueprint of the Technology-enabled Home Care Service

This research takes the health cloud as the main axis. We incorporate three technological solutions into the overall home care service process, design a new blueprint, and draw the whole service process in detail. We expected to provide a reference for home care service providers for applying smart technologies to their home care service models and create new value from managing their operations. Figure 4 shows the technology-enabled home care service blueprint.

## CONCLUSION

From the overall interview and the user journey map, this research found out that there are several problems that need to be overcome when introducing smart technologies into the current home care service. Firstly, the care receivers are mostly elderly people who don't know much about technology and are not good about using smart products. They are relatively easy to feel frustrated when using these technologies. Therefore, the companionship and guidance of family members and caregivers are particularly important. Only when the care receivers clearly understand the use of the products and accept the products from the bottom of their hearts can these technological solutions fully achieve their due efficacy. Besides, we found that the care receivers and their family members often face difficulty in product selection, installation, and setting. Therefore, recommendations or suggestions from third parties, such as doctors or experts, and perfect after-sales service of the smart technology providers (including assistance in installation, recording teaching videos, and dedicated customer service) are all opportunities for future improvement. At the same time, several limitations of this study should be addressed. First, a key limitation is the sample size. Since the elderly with different ages or levels of disability might have different needs and hold a different attitude toward smart technology products, future research could replicate this study using a larger and wider sample size. Second, in this study, we discussed the care receivers' attitudes toward smart technology products separately. However, they might feel stressed and offended because of using so many of these technologies in their lives. Hence, this issue should also be discussed and measured in the future.

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## Cybervetting Perceptions of Job Seekers in Saudi Arabia

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### ABSTRACT

Organizations have leveraged the use of social media (SM) in recruitment and selection to reach a wider pool of job applicants. The purpose of this study is to understand the perceptions of job seekers in Saudi Arabia using the job seekers' attitudes toward the cybervetting (ATC) scale. This research is a quantitative cross-sectional study in which an online questionnaire was distributed among the target population who were seeking jobs and using social media sites. The ATC was translated to Arabic language and back-translated to English language and administered to a sample of 160 job applicants. The results showed negative perceptions of social media use as a screening and selection tool. Moreover, respondents perceived cybervetting negatively on the three dimensions tested: justice perceptions, privacy invasion, and face validity. The findings of this study have practical implications for human resources managers about the use of social media as an employee selection tool.

*Keywords:* Cybervetting, social media, personnel selection, applicant reactions, Saudi Arabia, human resource management.

### INTRODUCTION

Around 98% of the Saudi Arabian population are Internet users, and 79.3% are active monthly social media users (Kemp, 2021; World Bank, 2020). Consequently, the availability of personal information of job seekers on social media platforms is tempting for employers to use in hiring decisions. The term cybervetting is used to describe using job applicants' online information in the selection process (Berger & Zickar, 2016; Backman and Hedenus, 2019). Mainly, Screening job applicants' social media accounts is increasingly common among employers (Cook *et al.*, 2020; Jacobson & Gruzd, 2020; Roth *et al.*, 2016; Van Iddekinge *et al.*, 2016). According to a CareerBuilder survey, 70 percent of organizations use social media in personnel selection (Nauen, 2017).

Saudis are fast to join popular social media platforms. These platforms may change from time to time as some gain popularity, and others disappear. Therefore, we are interested in non-professional social media platforms (e.g., Facebook, Twitter, Snapchat) where users share personal information publicly without particular attention to specific platforms. The social media users in Saudi Arabia are around 27.8 million users out of a 35 million population (KSA Social Media Statistics, 2021). The estimated numbers of social media users per platform are 31.40M for YouTube, 26.80M for Instagram, 25.92M for Facebook, 25.05M for Twitter, and 13.96M for LinkedIn (KSA Social Media Statistics, 2021).

While social media screening has taken its place as one of the selection methods used by employers, certain appraisal dimensions must be considered. Personnel selection methods are traditionally evaluated based on factors such as reliability, validity, and legal compliance (Gilliland, 1993). Applicant reactions to selection procedures became an additional factor in the 1980s (McCarthy *et al.*, 2017). They include "attitudes, affect, and cognition an individual might have about the hiring process" (Ryan & Ployhart, 2000, p.566). Conventionally, researchers studied justice perceptions following Gilliland's (1993) influential applicant reactions model, which was based on organizational justice theory. More recent research has examined other reactions in addition to fairness perceptions. McCarthy *et al.* (2017) listed "motivation, anxiety, and test/self-efficacy" as areas that gained increased attention in recent years.

Applicant reactions are related to critical organizational outcomes. Research findings support positive relationships between applicants' perceptions and their intentions to accept job offers, their performance on the assessments, and whether they would recommend the employer to others (Hausknecht *et al.*, 2004). McCarthy *et al.* (2017) reviewed 145 applicant reactions studies and reported significant relationships between job applicant reactions and employer attractiveness; fairness perceptions and each of job acceptance, job pursuit, and recommendation intentions; test anxiety and test performance; and test motivation and test performance among other outcomes.

Businesses are interested in how selection methods are perceived by applicants (McCarthy *et al.*, 2017). Applicant reactions influence the effectiveness of the selection process. The organization's ability to attract people interested in the employer's jobs depends on the applicants' current and previous experiences with that employer. The reactions of job candidates who inform their peers about their experiences, including their perceived fairness or the anxiety associated with some selection methods, may influence the quantity and quality of the organization's applicant pool. Qualified applicants may withdraw from the selection process to prevent negative experiences. Therefore, organizations interested in maintaining their positive employer brand – the

organization's image as an employer-of-choice – recognize the recruitment and selection function as the first point of contact between prospect employees and the organization.

Personnel selection tools have gone through interesting technological developments. Some advancements came as electronic versions of existing methods such as multimedia-enhanced situational judgment tests or online interviews. Others presented new selection methods such as social media screening, digital interviews, and gamification (Nikolaou, 2021). Technology developments in selection can be classified into the five categories presented by Woods et al. (2020): online applications, psychometric tests, digital interviews, gamified assessments, and social media assessments. The adoption of these new technology methods by organizations remains faster than research in the area. Therefore, researchers called for more studies to understand reactions to new technology selection methods, including social media assessments (McCarthy *et al.*, 2017). Woods et al. (2020) described the gap between research and practice in the area as widening and called for 'realignment' between selection practice and its evidence base.

## LITERATURE REVIEW

Backman and Hedenus (2019, p. 158) defined cybervetting as “the use of search engines and social media platforms to evaluate job seekers.” Understanding cybervetting can take different angles. From the organizations' side, evaluating 'fit' between the applicant and the job, team, and organization seems to be central. Berkelaar and Buzzanell (2014) conducted a qualitative study to understand employers' online job screening practices. Employers were found to engage in cybervetting to reduce the risk of investing in an unsuccessful hire. Other reasons they found shared among employers include maintaining employer image and reputation; saving time and cost compared to other selection methods and background checks; because cybervetting is fun; and because it is transformative (perceived features such as inevitable, available, and more accurate).

In a 2010 study commissioned by Microsoft Corporation to understand the role of individuals' online reputation, 1,106 HR professionals and hiring managers and 1,345 Internet users were interviewed in the United States, United Kingdom, Germany, and France (Cross-Tab Transforming Market Research, 2010). The study explored employers' hiring practices and Internet users' perceptions of how their online presence affects their reputation. Fewer than 15% of individuals believed that their online information could affect their chances of getting a job. As to recruiters, 70% of US recruiters have rejected job candidates based on information found online. The percentages for the remaining three countries ranged from 14% in France to 41% in the UK. Interestingly, while the US had the highest percentage of recruiters citing rejection based on online data (70%), the US Internet users were the least among the four countries to expect such practice. Only 7% of the surveyed US Internet users knew that their internet presence could negatively affect them. The survey results also show that employers use online information more as background checks than a method to evaluate specific competencies. The most common reasons for disqualifying candidates included inappropriate online comments, unsuitable photos, videos, and information, and concerns about the candidate's lifestyle. The study revealed that cybervetting practices commonly include people related to the job candidate. A significant percentage of employers, ranging from 11 percent in France to 43 percent in the US, have rejected candidates based on online posts by the candidate's friends and relatives.

While statistics show that most employers are using social media for screening candidates, research evidence on the reliability, validity and applicant reactions of cybervetting is limited (Roth et al., 2016). Selection methods are tested for their reliability and validity to ensure the accuracy and fairness of the hiring procedure. One issue related to the cybervetting process is that it lacks consistency. When a selection procedure is highly subjective, as in the case of cybervetting, the reliability is expected to be below. Reliability entails differences in a rater's screening process from one job candidate to another, as well as variances in procedure among raters. A recent study by Schroeder et al. (2020) tested whether the reliability of cybervetting can improve with increased structuring. It is repeatedly proposed that cybervetting is similar to job interviews in that both involve processing large amounts of qualitative information (Roth et al., 2016; Schroeder et al., 2020). There is accumulated research evidence supporting adding structure to job interviews to improve the reliability and validity of the interviews (Schmidt & Hunter, 1998). Schroeder et al. (2020) tested three structure conditions: specifying and defining the candidate's job characteristics under evaluation, providing raters with a rating scale for each characteristic, and basing the judgment on specific profile features. However, the study showed that increasing the process structure did not improve the psychometric properties of cybervetting. Other studies found similar results (Cook et al., 2020).

A selection method's validity is related to how accurate the measure compares job candidates and predicts their future performance. Selection methods are tested against a job success criterion such as job performance. Cybervetting decisions depend primarily on the impressions of the evaluator. The assessment is prone to be affected by personal biases, the randomness of the information available, and the accuracy of how candidates represent themselves in social media (Cook et al., 2020). Research on the validity of cybervetting and other new technology selection methods is limited (Woods et al., 2020).

Roth et al. (2016) listed three factors of uniqueness for cybervetting: it does not elicit job-related information from candidates, there is a mismatch between the purpose of the tool and how it is used, and there are difficulties in standardizing the screening process. From an applicant reactions perspective, cybervetting is unique because applicants do not directly experience the selection technique. Among traditional and non-traditional selection methods, a few can be conducted without the knowledge or consent of job applicants. Therefore, it is common for cybervetting researchers to address ethical and privacy concerns (Cook et al., 2020; Roth et al., 2016; Woods et al., 2020). In one study, applicants reacted negatively to cybervetting due to the invasion

of applicants' privacy (Stoughton et al., 2015). Overall, it is early to judge the applicants' perceptions of cybervetting, but they are likely to be negative (Stoughton, 2016; Woods et al., 2020).

Several applicant reactions frameworks were developed to guide theory in the field (Gilliland, 1993; Hausknecht *et al.*, 2004; McCarthy et al., 2017; Ryan & Ployhart, 2000). To understand perceptions of cybervetting, the model developed by Hausknecht *et al.* (2004) can be useful. The model builds on previous models (Gilliland, 1993; Ryan & Ployhart, 2000) and identifies four categories of antecedents of applicant perceptions. The antecedents related to justice perceptions, face validity, and privacy invasion are of particular interest to us.

## THEORETICAL BACKGROUND AND HYPOTHESES

### Justice Perceptions

Organizational justice theory classifies justice perceptions into procedural justice, interpersonal justice, informational justice, and distributive justice. Gilliland's (1993) applicant reactions model translated the four dimensions into justice rules. The satisfaction or violation of these rules amounts to the overall fairness perception of the selection process and outcome. Hausknecht *et al.* (2004) incorporated Gilliland's (1993) justice rules in their comprehensive model.

In the personnel selection context, distributive justice is related to the fairness of the hiring decision. But since the number of qualified job candidates who go through the hiring process is usually higher than the number of positions available, we turn to the process by which the hiring decision was made. In the cybervetting literature, there is particular interest in procedural justice (Cook *et al.*, 2020). The uniqueness of social media screening as a selection procedure, as explained earlier, draws attention to procedural justice perceptions. For example, using a social media platform that was created and used for social and recreational purposes raises questions about the appropriateness of the selection procedure. In fact, the comments received from participants of this study support procedural justice concerns. One comment translates to: "Social media platforms can't be a method for hiring. People present different personas in social media than in real life. Social media are mostly recreational tools" (Anonymous participants). Another participant commented: "Never should social media platforms be a measure of one's personality." Therefore, we follow Cook *et al.* (2020) in defining justice perceptions of cybervetting as applicants' fairness perceptions of social media as a method for personnel selection. Our first hypothesis is as follows:

H1: Job applicants will have negative justice perceptions towards cybervetting

### Face Validity

Hausknecht *et al.* (2004) presented the job-relatedness antecedent as having two factors: face validity and perceived predictive validity. The former describes applicants' perceptions of the similarity of the content of the selection method to the content of the job. It is distinguished from content validity in that content validity is evaluated by experts, whereas face validity is perceived by applicants. Cook *et al.* (2020), in the job seekers' attitude toward cybervetting (ATC) instrument, defined face validity as perceived predictive validity. Consequently, the face validity factor of the ATC has three items related to the perceptions of cybervetting's validity to predict the dependability, task performance, and personalities of future employees. Aguado *et al.* (2016) found that job seekers showed more negative reactions to non-professional SM sites (i.e., Facebook) compared to professional SM sites (i.e., LinkedIn) when they are used as selection tools. We postulate the second hypothesis as follows:

H2: Job applicants will have negative perceptions towards cybervetting as a valid method of selection

### Privacy Invasion

Privacy is classified into different dimensions in the literature. Harris *et al.* (2003) distinguish informational privacy as the most relevant dimension for internet-based selection. Informational privacy is defined as the "perceived control over the conditions of release, use, retention, and disposal of personal data" (Cho and LaRose, 1999, as cited in Harris *et al.*, 2003). In the case of cybervetting, applicants have limited control over the release and use of their social media information. Unlike other recruitment and selection procedures where applicants submit information to employers and provide answers to questions, Cybervetting takes away applicants' control over what information is provided. Gilliland (1993) proposed invasion of privacy as a potential factor affecting applicant reactions, although he did not list it among the ten justice rules in his model. According to Gilliland, applicants may perceive a selection method as invasive of their privacy either because of the type of the method or because of the way it was administered. However, Hausknecht et al. (2004) included intrusion of privacy as an antecedent of applicant perceptions. Our third hypothesis is as follows:

H3: Job applicants will have negative perceptions towards the privacy invasion of cybervetting

Finally, we expect job applicants to have an overall negative perception of cybervetting, as in the fourth hypothesis:

H4: Job applicants will have negative perceptions towards cybervetting

## RESEARCH METHODOLOGY

### Instrument

An Arabic translation of the job seekers' attitudes toward cybervetting (ATC) scale, which was developed and validated by Cook *et al.* (2020), was used to measure job seekers' perceptions of employers' use of social media as a selection tool. The ATC was translated from English to Arabic and back-translated to ensure equivalence. The original instrument consisted of 14 items assessing three perception dimensions: perceived justice (PJ) measured by six items; privacy invasion (PI) measured by five items; and face validity (FV) measured by three items. The whole questionnaire consisted of two parts. The first part included the detailed items of the measurement scales. The responses were measured using a five-point Likert scale (1=*strongly disagree*,

5=*strongly agree*). The second part collected demographic and personal information, including gender, age, employment status, education, marital status, privacy settings of social media account, and frequency of social media use. The complete questionnaire is shown in the Appendix.

### Participants

The sample consisted of 160 Saudis (54% female). The majority of participants used social media on a daily basis (94%). Age groups were from 20 to more than 40 years old (16% younger than 25, 53% from 25 to less than 30, 28% from 30 to less than 40, and around 3% were 40 years old and above). Unemployed participants were 36%, while full-time employees were 57.5%, 5.6% self-employed, and 1.3% part-time employees. The privacy settings of respondents' social media accounts ranged from all public (22.5%) to all private (25%), with 52.5% having both private and public accounts. Table 1 summarizes the frequency and percentage of participant characteristics.

Table 1: Demographic characteristics of participants

Variable	Values	N	%
Gender	Male	74	46.3
	Female	86	53.7
Age (years)	20-24	26	16.3
	26-30	85	53.1
	30-40	45	28.1
	Above 40	4	2.5
Employment	Unemployed	57	35.6
	Full-time job	92	57.5
	Part-time job	2	1.3
	Self-employed	9	5.6
Education	Associate	3	1.9
	Bachelor	127	79.4
	Graduate	30	18.8
Marital Status	Single	95	59.4
	Married	62	38.8
	Other	3	1.9
Privacy Setting	Private account	40	25.0
	Public account	36	22.5
	Hybrid	84	52.5
Frequency of Social Media Use	Daily	150	93.8
	Weekly	8	5.0
	Monthly	1	0.6
	Rarely	1	0.6

## Results

### Exploratory Factor Analysis

The ATC scale was subjected to factor analysis in order to group the scale items into meaningful clusters and verify their unidimensionality and check the construct validity. Specifying three factors to extract, factor analysis was conducted via principal component analysis with orthogonal varimax rotation. Because the Communality of PI5 was very low (i.e., 0.261), it was dropped. A subsequent factor analysis was conducted with the remaining 13 items. Item PJ4 was also dropped because it had high cross-loadings on both privacy invasion (PI) and perceived justice (PJ) factors. Some researchers have suggested various cutoff points for the retention of items depending on the value of factor loadings, varying from 0.35 to 0.50 (Hair *et al.*, 1998). In this study, loadings of 0.50 or more were considered practically significant. Factor analyses resulted in a solution with three factors with eigenvalues over 1.0, explaining 69.59% of the variance. Table 2 shows the exploratory factor loadings after dropping items PI5 and PJ4.

### Reliability Analysis

The study constructs were then tested for reliability. To check the reliability of each factor, internal consistency using Cronbach's Alpha analysis was computed. The Alpha coefficients ranged between 0.829 and 0.883, which were all above the value of 0.6 (Nunnally & Bernstein 1994). This indicates that all items in the factorial groups in this study were reliable measures. An examination of the correlation coefficients showed that none of the pairwise correlations were greater than 0.7. Therefore, we conclude that there are no multicollinearity issues associated with the data. Descriptive statistics, correlations, and Cronbach's Alpha reliability coefficients were presented in Table 3.

### Common Method Bias

Common method bias (CMB) is prevalent in empirical research. The existence of CMB can inflate relationships among study variables and create biased estimates of reliability and validity, especially for self-reported data collection methods. This study employed Harman's Single-Factor Test (Chang *et al.* 2010) to evaluate the possibility of having CMB in this study. The

procedure to test CMB is to run exploratory factor analysis and then examine the amount of variance explained by the single factor. It is found that the largest unrotated factor accounts for 37.1%, and the rotated factor accounts for 25.4%, below the cutoff value of 50% (Aguirre-Urreta and Hu, 2019). This indicates that the CMB is not present in this study.

Table 2: Exploratory factor analysis

Constructs	Mean	SD	Factor Loadings		
			PJ	PI	FV
<i>Perceived Justice (PJ)</i>					
PJ2	1.89	1.21	.842	-.050	.060
PJ1	2.31	1.36	.802	-.063	.210
PJ3	2.16	1.28	.775	-.104	.347
PJ5	2.35	1.28	.698	-.114	.412
PJ6	3.28	1.59	.589	-.077	.142
<i>Privacy invasion (PI)</i>					
PI2	2.53	1.53	-.154	.874	.099
PI3	2.46	1.50	-.093	.848	.010
PI1	2.21	1.45	-.098	.780	.174
PI4	3.36	1.62	.016	.735	-.220
<i>Face validity (FV)</i>					
FV1	1.70	1.10	.303	-.003	.868
FV3	1.56	1.12	.299	-.045	.866
FV2	1.83	1.18	.204	.141	.811
Eigenvalue			3.05	2.69	2.61
Variance explained (%)			25.43	22.43	21.73
Cumulative variance explained (%)			25.43	47.86	69.59

Table 3: Mean, standard deviation, intercorrelations, and Cronbach's alpha reliability

Dimension	No. of Item	Mean	SD	Correlation Coefficients			Cronbach's Alpha
				PJ	PI	FV	
PJ	5	2.396	1.048	1.00	-.193 <sup>a</sup>	.549 <sup>b</sup>	0.834
PI	4	2.641	1.239	-.193 <sup>a</sup>	1.00	.016	0.829
FV	3	1.698	1.019	.549 <sup>b</sup>	.016	1.00	0.883

<sup>a</sup>Correlation is significant at  $P \leq 0.05$ ; <sup>b</sup>Correlation is significant at  $P \leq 0.01$

### Hypothesis testing

A one-sample t-test was used to test the four hypotheses. The hypothesis testing of overall cybervetting showed a significant difference in the means. Respondents had negative perceptions of cybervetting. Hausknecht *et al.* (2004) identified perceived justice, privacy invasion, and face validity as determinants of applicant perceptions. Our study supports the predictions of Hausknecht *et al.* (2004). Job applicants perceived cybervetting negatively across all three factors: perceived justice, privacy invasion, and face validity. The one-sample t-test showed support to each of the four hypotheses. The t-tests and significance levels are shown in Table 4.

Table 4: One-sample t-test of cybervetting

Test Value = 3						
Dimension	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Perceived Justice	-7.288	159	.000	-0.60375	-0.7674	-0.4401
Privacy Invasion	-3.670	159	.000	-0.35938	-0.5528	-0.1660
Face Validity	-16.165	159	.000	-1.30208	-1.4612	-1.1430
Overall Cybervetting	-13.685	159	.000	-0.75507	-0.8640	-0.6461

## DISCUSSION AND CONCLUSION

This study contributes to a need highlighted by researchers to understand applicant reactions to new technology selection methods. It also provides evidence for applicant reactions from Saudi Arabia. A few studies of applicant reactions were conducted in Saudi Arabia, and -to our best knowledge- none studied perceptions of cybervetting or new technology selection methods. The purpose of our study was to understand how job seekers in Saudi Arabia perceived cybervetting relative to three dimensions: fairness of the method, face validity, and invasion of applicants' privacy. The study showed that job applicants in Saudi Arabia had negative reactions to cybervetting. Our sample of job applicants found cybervetting to be unfair, privacy-invasive, and of low face validity. These findings were consistent with past research (Madera, 2012; Stoughton *et al.*, 2015).

The results of this study were in support of the model of applicant reactions (Hausknecht *et al.*, 2004). The model proposed that negative applicant perceptions can be caused by several procedural occurrences in the selection process. Our study relates the overall negative perceptions of cybervetting to three perceived procedure characteristics from the model. First, the job-relatedness procedural justice rule was violated. Participants perceived cybervetting as an invalid method to predict and infer about job applicants. This was present in the face validity measurement. Second, the overall procedural justice was perceived negatively. According to the model, procedural justice rules are antecedents of applicant reactions.

The ATC provides a general measure of procedural justice. Further research might investigate two candidate components of procedural justice that can have a direct effect on job seekers' perceptions. Namely, the applicants' opportunity to perform and the consistency of administration of the selection method (Gilliland, 1993). When job candidates go through the selection process, they prefer to have opportunities to show their knowledge, skills, abilities, and other characteristics (KSAOs). Cybervetting does not give job seekers the opportunity to perform or to select what KSAOs to present to employers.

Also, cybervetting is a highly subjective form of assessment. Employers looking through social media accounts engage in an unsystematic process. Personnel selection is a process of comparison and prediction. That is, employers use their selection procedures to compare individuals in their applicant pool and to predict job success criteria such as future job performance. Consistency in personnel selection means "ensuring those decision procedures are consistent across people and over time" (Gilliland, 1993). It is difficult to ensure consistency in cybervetting. The information provided by social media users is different in terms of the amount of information, the sensitivity of the information, the nature of use, the account privacy settings, the format of the information posted, and the time of posting. Also, the assessment process- without a set procedure- can be described as random. When the consistency of administration rule is violated, there is an increased chance for negative applicant perceptions (Gilliland, 1993; Hausknecht *et al.*, 2004).

The third perceived procedural characteristic is the invasion of privacy. This antecedent is also consistent with Hausknecht *et al.*'s (2004) model. Invasion of privacy was found to affect the perceptions of job applicants to cybervetting negatively. Job seekers may view employers who are invasive of their privacy as less attractive. In their study, Stoughton *et al.* (2015) found privacy intrusion to be a mediator to the relationship between cybervetting and organizational attraction and intentions to litigate.

The current study provides insights to human resources (HR) professionals and hiring managers about the use of social media as a selection tool. Understanding applicant reactions to the different selection methods affect the organization's ability to attract and retain talent. Applicants' job pursuit intentions may decrease for organizations that engage in cybervetting (Madera, 2012). The recruitment and selection function manages the organization's perception as an employer. In that sense, applicant reactions should take weight in evaluating the selection method since qualified applicants might drop out of the selection process, and the intentions to apply to the organization are affected by the recruitment and selection procedures. This is especially true for passive job seekers who are currently on the job and are targeted by organizations for their talent. Passive job seekers have fewer motives to engage in tedious or disrespectful selection processes. HR managers who want to ensure the fairness of HR processes and outcomes should be concerned about such methods.

Given the indications of unfavorable applicant reactions and the limited knowledge available on the effectiveness, legal implications, and potential assessment biases involved, employers should be cautious with cybervetting. Tools that are used to make selection decisions should be taken seriously by organizations since such decisions affect organizational capabilities and competitiveness. HR policies can be issued to prohibit such practices in organizations. HR departments are responsible toward their community and stakeholders to protect the privacy of current and potential employees.

Moreover, there are factors of organizational well-being involved. Several meta-analytical studies supported the effect of perceptions on job pursuit intentions and whether applicants accept job offers or recommend the organization to others (McCarthy *et al.*, 2017). Furthermore, there is significant evidence relating applicant reactions to their job performance after they are hired (Konradt *et al.*, 2017; McCarthy *et al.*, 2017). The selection process affects the mutual expectations, or the psychological contract, between the employee and the organization. Since the recruitment and selection process is their first contact with the organization, employees' attitudes toward the organization can result from their reactions to the selection process.

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*Which of the following Social Media Sites do you use at least once a month?*

- Twitter
- Snapchat
- Instagram
- Facebook
- Other

*What is your current job?*

- Full-time
- Part-time
- self-employed
- unemployed

*What are the privacy settings of your SM account?*

- Private
- Public
- Hybrid

*Frequency of Social Media use:*

- Daily
- Weekly
- Monthly
- Rarely
- Never

*What is your marital status?*

- Single
- Married
- Other

## Driving Forces for Digital Transformation – Case Studies of Q-Commerce

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### ABSTRACT

Companies want to leverage emerging technologies to achieve digital transformation, but most of them are reluctant to take action. This study investigates the driving forces behind digital transformation investment by studying how HKTVMall and Pandamart have invested in new digital technologies to enable q-commerce in Hong Kong, China. Though Pandamart follows a modular approach and HKTVMall follows a staged approach to achieve digital transformation, we have found that in both cases, digital transformation has been driven by economic factors (cost reduction and revenue generation), social factors (changing demographic characteristics and changing customer behavior), and technological factors (proprietary technology advantages and new digital technology capabilities).

*Keywords:* Digital transformation, q-commerce, IT investment, innovation, IT infrastructure.

### INTRODUCTION

Digital transformation has attracted a lot of interest from academics and industrial practitioners due to its profound impact on organizational and industrial transformation. It can change the way individuals and organizations perceive, seize and transform opportunities brought by new digitalization, causing deep changes at multiple levels and creating new ways of innovation (Appio *et al.*, 2021). A recent survey suggests that companies that use new digital technologies or have invested more in such technologies are twice more likely to have a higher revenue growth than their peers (LaBerge *et al.*, 2020).

The outbreak of the COVID-19 pandemic has further increased the urgency for studying digital transformation. A large percentage of the working population has to work remotely due to mandatory government restrictions or voluntary precautions against the pandemic (Nagel, 2020). The need for social distancing has forced a lot of customers to rapidly move to use online channels, leading to many companies' rapid shift toward interacting with customers through digital channels (LaBerge *et al.*, 2020).

The outbreak of the pandemic has also changed executives' views of IT investment. According to McKinsey's survey results, in 2017, half of the executives put cost savings as the priority for their digital strategies, but only 10 percent view technology in this way in 2020. Thirty percent of respondents aimed to modernize core technology capabilities, such as keeping up with competitors, 38 percent aimed to make IT a competitive advantage, and 19 percent aimed to rebuild the entire business around digital technologies. This mindset shift is most common among executives whose organizations were losing revenue before the crisis began. (LaBerge *et al.*, 2020).

Though companies are aware that digitalization will disrupt their industries and are willing to prioritize investment to obtain new opportunities, most of them do not know or are not ready to use such opportunities to achieve innovation and value creation (Appio *et al.*, 2021). How the alignment of business and IT strategies can improve firm performance has been an important research topic for many years (e.g., Sabherwal *et al.*, 2019), but the findings are inconclusive. This is further complicated by socio-technical factors. For example, well-established companies have found their ability to compete digitally is hidden by legacy systems and ways of working instead of the lack of strategic thinking (Ross, 2020). Therefore, new digital systems can improve performance, but there is still a lack of understanding of how and under what conditions firms leverage these new digital systems (Anand *et al.*, 2020).

To address this issue, our study investigates the driving forces behind two companies' investments in digital technologies in Hong Kong. With one of the highest mobile penetration rates in the world, HK has a well-established infrastructure suitable for e-commerce development. E-commerce has grown rapidly in HK in recent years and is expected to grow further. According to Euromonitor (2020), the compounded annual growth rate (CAGR) was 10% between 2014 and 2019, which is expected to reach 12.6% between 2019 and 2024. The e-commerce market value will reach HKD5.5 billion by the end of 2024. The two companies under research are HKTVMall and Pandamart. Both companies are committed to using new digital technologies to develop q-commerce businesses in HK in recent years.

The rest of the paper will be organized as follows: In the next section, we will first review the literature on digital transformation and discuss the incentives behind IT investments from the financial, social, and technological perspectives.

Then, we will move on to discuss the two case studies, HKTVmall and Pandamart. This is followed by an analysis and discussion of the driving forces behind their IT investment decisions. The last section will conclude this study.

## LITERATURE REVIEW

### Digital Transformation

Digital transformation is defined as “organizational change that is triggered and shaped by the widespread diffusion of digital technologies” (Hanelt et al., 2020) in order to “develop a new digital business model that helps to create and appropriate more value for the firm.” (Verhoef *et al.*, 2021)

Digital transformation is driven by the advent of new digital technologies, changing customer behavior, and the competitive landscape (Verhoef *et al.*, 2021). Emerging digital technologies create new opportunities for companies. Robotics replace humans to save costs in service delivery, and AI and blockchain are used to optimize logistics streams and reduce supply chain costs. Customers have benefited from the on-demand economy enabled by new digital technologies. New social media tools and search capabilities allow information sharing among customers so that customers become more connected and informed than before. With the support of the new digital technologies, customers can participate in designing and customizing the products they buy, completing the last-mile delivery activities, and sharing their user experiences. New digital technologies have also blurred industry boundaries, enabling IT-enabled companies to enter the competitive landscape of other industries.

Digital transformation is a multidisciplinary issue that has an impact on a company’s IT infrastructure, corporate strategy, supply chain management, and marketing strategy. New digital technologies have changed a company’s relationships with its stakeholders. Customers can become co-creators of new products and services, competitors can become collaborators, and suppliers can be bypassed or acquired through vertical integration.

But the use of new digital technologies is not always associated with a positive impact on firm performance. Cappa et al. (2021) study the impacts of big data analytics on firm performance, i.e., using mobile apps to collect private data from customers. They suggest that big data need to be reliable and rich enough to provide insightful information. Otherwise, the costs and risks of collecting, storing, and using the data can harm firm performance.

Therefore, how companies can invest in new digital technologies to leverage existing resources to gain a sustainable competitive advantage (Verhoef *et al.*, 2021) remains unanswered. Appio *et al.* (2021) also call for theoretical and empirical research on how companies innovate and compete in the digital world and how digital technologies have changed the development processes of new products and services.

### IT Investment Decisions

Firms choose IT investment to either conform to or deviate from industry norms as a response to competitive pressure or to support their value creation activities (Xue *et al.*, 2012). When making IT investment decisions, companies have a sense-making structure that is made up of a technical structure based on their technical foundations and a social structure built on their behavioral norms and relational ties (Tan *et al.*, 2020). The expected value of IT investments can be understood from economic, technical, and social analysis because the value is a dynamic negotiation process between the theoretical understanding of “value” proposed and supported by science and the application of “value” proposed by the industry and perceived by end-users (Nicolescu *et al.*, 2018).

### Financial factors

IT investment can be driven by financial performance shortfalls. IT-enabled problemist search can improve problem-solving capabilities and support product innovation by enhancing knowledge management and facilitating knowledge sharing with business partners (Dong *et al.*, 2021). Business intelligence and analytics systems have been used for problemist searches when there are sustained failures in financial performance and/or operational performance (Anand *et al.*, 2020).

Xue et al. (2012) have found a negative co-relation between firms’ engagement in real earnings management (REM) and the extent of commitment to planned investments in IT infrastructure. They find that IT decentralization weakens the negative association between REM and IT investment commitment, and other corporate governance mechanisms, such as institutional ownership and takeover threats, can complement IT decentralization to further mitigate the negative association.

Additionally, the first-mover advantages of IT investment are found to be related to the industry features. The declining costs of IT investments will lower the average price per unit quality and benefit consumers, but whether the lower costs of IT investments can benefit companies depend on whether they are service quality- or price-sensitive markets (Demirhan &., 2005).

### Social factors

IT investment decisions should take into account the hidden social costs and benefits, such as employees’ expertise, task interdependencies, and the degree of change caused by workflow innovation (Ryan & Harrison, 2000). Sabherwal et al. (2019) suggest the positive effect of IT investment on firm performance depends on the social environment. Compared to a stable, simple, and munificent environment, the positive effect of IT investment on firm performance is more significant in a dynamic,

complex, and hostile environment. On the individual level, Park et al. (2016) find that emotional response, like regret, is an important element of the sense-making process when making an IT investment decision.

### ***Technological factors***

IT systems can help companies to improve efficiency and develop R&D capabilities. Xue et al. (2012) categorize IT investments into exploitation IT investments and exploration IT investments. Exploitation IT investments enhance operational efficiency, while exploration IT investments enhance innovation by accelerating new product and process innovations.

Investments into different types of IT investments are determined by corporate strategies, for instance, to achieve cost leadership or innovation leadership (Aral & Weill, 2007). Aral and Weill (2007) show that different strategic purposes will determine their IT investment allocations and their IT capabilities in specific IT assets, leading to performance differences. Xue *et al.* (2012) find that IT investment often aims to increase efficiency if the industry and its revenue grow steadily in a relatively stable business environment. If the industry's business environment is dynamic, IT investment often aims to improve innovative capabilities, such as new product and service development and exploration of growth opportunities.

### **Investment Decision-Making in Digital Transformation**

To achieve digital transformation, Li (2020) has identified three innovation approaches emerging in leading organizations, including (1) experimental innovation using experiments to evaluate and recalibrate strategy and guide implementation, (2) radical transformation by taking out a series of incremental interlocked steps and (3) dynamic sustainable advantages through an evolving portfolio of temporary advantages. A further review of the literature suggests two general approaches to achieve digital transformation, the staged approach, and the modular approach.

#### ***The staged approach***

Companies adopting this strategy believe that they need to go through different stages to achieve digital transformation. They need to first develop the necessary technical and social structures to acquire the necessary capabilities, processes, and routines to accommodate digital transformation (Appio *et al.*, 2021).

Dremel et al. (2017) have identified three stages that a traditional auto manufacturer, AUDI AG, has created big data analytics capabilities by undergoing substantial organizational transformation and developing new organizational structures and business processes. The first stage is to develop big data analytics capabilities by recruiting talents and analyzing customer data. Then the next stage is to adjust existing organizational structures and IT infrastructures in order to develop key digital capabilities, providing data-driven insights for decision making. The final stage allows the company to centrally and strategically exploit big data analytics in a scalable and professional way, leading to new market offerings.

Digitization, digitalization, and digital transformation are other staged approaches suggested by Verhoef *et al.* (2021). They argue that digitization and digitalization should be carried out before digital transformation. Companies should first encode analog information into a digital format to allow computers to use the data. Then, companies should use the technologies to alter existing business processes. Finally, to achieve digital transformation, companies should have digital assets and develop capabilities related to digital agility, digital networking, and big data analytics.

#### ***The modular approach***

The modular approach divides the overall task into small modules, using new digital technologies to develop temporary advantages. Relying on successive temporary advantages, companies can develop an evolving IT portfolio to create sustainable advantages dynamically and cumulatively (Li, 2020). Unlike the staged approach, the modular approach invests more in R&D than in developing the social and technical infrastructures.

Markins (2017) argues that the plan-then-do approach, such as the staged approach, is dangerous and obsolete because 40% of the strategy's potential value was found to be lost during strategy implementation. Companies should view strategy as a direction or agenda for making investment decisions instead of a plan. The strategy should be considered as a portfolio of options, instead of bonds, which managers should make decisions based on today's tumultuous environment and value flexibility in choosing the way to achieve the strategic objectives. With effective response mechanisms in place, companies can adopt agile planning, learning by testing. Webvan was the world's first online grocery delivery business established in 1996 and ceased operations by 2001, which is used by Markins (2017) to illustrate the deviation between plan and reality. After promising to provide customers with the best quality groceries at the cheapest price, Webvan made a substantial capital investment in developing a nationwide system of distribution centers equipped with stock-picking robots. To justify its investment, Webvan made a bold forecast of future usage, order sizes, and costs without using any reliable proxies. Eventually, it turned out that usage and order volumes were much lower than expected, while capital investments were much higher than expected.

Companies with adaptability, agility, and ambidexterity are found in a better position to use new digital technologies to sustain their innovativeness than their counterparts (Scuotto *et al.*, 2021). They can adapt their structure to market changes and have an open mind to balance infrastructure investments and R&D investments when operating in an uncertain and complex environment.

## CASE STUDIES

To understand the driving forces behind companies' investment to achieve digital transformation, we will describe two HK-based q-commerce case studies which have used different approaches: HKTVMall adopts the staged approach, and Pandamart follows the modular approach. These two cases are chosen because they are operating in the same industry in the same city while adopting different approaches to use new digital technologies to achieve q-commerce. Moreover, q-commerce is an emerging phenomenon in HK, so both companies can be regarded as the pioneers in this area. Therefore, it is interesting to study the driving forces behind their investment decisions.

### Q-Commerce

To differentiate from traditional brick-and-mortar supermarkets and traditional e-commerce models, as shown in Table 1, we define quick commerce (q-commerce) as “a fast form of on-demand delivery which can deliver goods ordered online by customers to customers in less than one hour.”

Compared to traditional e-commerce models, q-commerce highlights speed. In traditional business models, cost-saving is a priority, so companies need to handle large volumes of products, use large warehouses and optimize load. In q-commerce, as delivery time is a key consideration of customers when making purchase decisions, response time is a priority, so companies use micro-hubs and rely on couriers specialized in last-mile deliveries (Villa & Monzón, 2021).

The demand for speedy delivery is driven by busy urban lifestyles, small families, an aging population, and q-commerce is enabled by the on-demand economy and the capability of instant deliveries (Villa & Monzón, 2021). Besides speed, convenience, consistency, friendliness, and human touch have been identified as the most aspects of customer experience (PWC, 2018).

Table 1: Different Generations of E-Commerce.

	<b>Brick-and-mortar Supermarkets</b>	<b>E-Commerce</b>	<b>Q-Commerce</b>
<b>Way of shopping</b>	In-store self-service	Online order and delivery within a few days	Online order and delivery within one hour
<b>Method of delivery</b>	Delivery truck	Delivery truck	Two-wheeled vehicle
<b>Presence</b>	Megastore	Mega warehouse	Small local store or micro-hub
<b>Target customers</b>	Three or more people households	Three or more people households	Single-person and two people households
<b>Customer preferences</b>	Price sensitive and discount matters	Price sensitive and discount matters	Time-sensitive and speed matters

Source: This study.

The COVID-19 pandemic has also encouraged new customers to purchase online for the first time. Due to social distancing measures, more and more customers have realized the convenience of online shopping and reduced their concerns about security and privacy. Research shows that customers have not rushed back to physical stores in China even after the lockdown ended. Even after the pandemic is over, online sales in the four main consumer categories, including food and beverages, pharmaceutical and medical suppliers, personal care, and pet products, are expected to continue to grow (Escudero *et al.*, 2020).

But the development of q-commerce is facing similar challenges to urban e-commerce distribution, such as small volumes, high resupply frequencies, complex delivery addresses, low stock levels, and timely deliveries. Therefore, companies have used new methods in urban logistics, such as lockers, collection points, and mobile warehouses, to reduce the number of vehicles, trips, and failed deliveries (Villa & Monzón, 2021).

### The HKTVMall Case

*(We embrace a clear goal to build a large scale “infrastructure” for online shopping platform in Hong Kong, to build an “infrastructure” that competitors have to spend a long time to catch up with, to build an “infrastructure” that our Hong Kong retailers have not been trying to develop with science and technology over the past decades. These “infrastructures” include a system that handles and combines the order, picking, return, exchange, and payment for our 2,000+ merchants; automated warehousing, pick & pack system that keeps 20,000 to 30,000 products and processes more than 30,000 orders daily; and a logistics and delivery system that collects and disseminates products from multiple merchants and consolidates into one single order. While you may not be able to imagine the difficulties and complications, this explains why there is no large-scale online shopping platform in Hong Kong until today.*

—Ricky Wong, Founder, HKTV (Wong, 2018)

HKTVmall is the largest e-commerce platform in Hong Kong, operating 24 hours to provide a “one-stop-shop” platform to local customers.

After a trial operation in December 2014, HKTVmall was formally launched in February 2015 under the slogan “We Sell Whatever You Can Imagine.” In 2018, HKTVmall decided to use technologies to reshape retail patterns in Hong Kong after observing the changes in consumer behaviors in HK. The total retail sales in HK dropped from HKD493 billion in 2014 to HKD446 billion in 2017, and HK consumers were increasingly using overseas online platforms. Customers paid fewer visits to physical retail stores but bought goods online and received them from courier trucks or pick-up centers. In HK’s major commercial centers, Tsim Sha Tsui and Causeway Bay, the number of local consumers and high-spending China mainland visitors from top-tier cities had dropped (HKTV, 2018a).

From the start, HKTV set the objective to build long-term capacity by investing a large proportion of capital in logistics infrastructure. With its own infrastructure, HKTV can maintain its independence and make it difficult for its competitors to replicate its business model. Their mission is “to build an Ecosystem to transform Hong Kong business operation, trading, retail, finance, and daily life onto a digital online platform” (HKTV, 2018b).

In 2018, HKTV planned a four-stage operational model in order to break even and become profitable. Stage one started with the cost control for warehousing, packaging, and delivery services; Stage two was to lower the operation costs of HKTVmall, covering merchandising, marketing, new customer acquisition, and customer services; Stage three focused on supporting functions, including finance, administration, and talent management; and finally Stage four focused on research and development, including information technology and new service development (Wong, 2018).

The company became profitable for the first time in 2020, partly due to the outbreak of the pandemic. Now the company has partnered with over 4,200 merchants, providing more than 500,000 products on its website. The products on offer include groceries, beauty products, electrical appliances, houseware, toys, books, and insurance. The number of orders processed monthly is more than 580,000 on average now (HKTV, 2021). In 2020, HKTVmall ranked first in Top Trending Shopping Sites and second in Top Trending Keywords of Google Hong Kong Year in Search 2020.

#### ***HKTV Shopping Network Co. Ltd. and HKTVexpress – Online shopping malls***

As HKTVmall’s online shopping malls, HKTV Shopping Network Co. Ltd. and HKTVexpress are featured with an online-to-offline approach and one-click purchase. Adopting an online to offline (O2O) approach, HKTVmall has physical stores, or so-called concept stores, so customers can choose to have the goods delivered to their homes or pick up from concept stores. In 2016, HKTVmall opened the first concept shop in North Point on HK Island to provide an offline customer experience. The size of the store is 200 square feet with fewer than five salespeople. Salespeople can use the 50 tablets available in-store to help customers shop on HKTVmall.com. They opened the second one in Ap Lei Chau in June 2017. These concept stores are developed mainly for promotion and pick-up services, but they have also helped to boost sales. With the opening of the second concept store, for instance, the sales of Ap Lei Chau increased from HKD0.3 million to HKD1.3 million in one month’s time (Cui, 2017).

HKTVmall also hopes concept stores can improve customer experience by giving customers more choices. Customers can place orders anytime online and pick them up in stores, and they can also directly buy the goods onsite. The number of O2O concept stores reached 64 in 2020, selling groceries, beauty and health products, electronics, mother and baby products, and homeware (HKTV, 2021). Since February 2020, HKTVmall has added a total of 115 pick-up points to its network by partnering with well-known chain retailers, including Hung Fook Tang, Baleno, GIORDANO, CATALO, and Foodwise. HKTVmall customers can choose these retailers’ outlets to pick their orders.

Self-pickup of goods can reduce transportation costs and speed up delivery, which enables the company to sell even frozen meat and fresh vegetables. In 2017, HKTVmall delivered seafood directly from Japan, bringing hairy crabs from Hokkaido. In January 2021, HKTVmall launched its first Online Flower Market to support local florists by offering a special commission rate. This broke the traditional limitation for retail to have live streamlining on both HKTVmall Live Shopping Channel and social media page for promotion. By partnering with merchants, HKTVmall is able to offer more varieties of products. In 2018, for example, compared to the traditional online supermarkets offering 40,000 different product items (or SKUs), HKTVmall was able to offer nearly 180,000 SKUs, including 20,000 from its own warehouses and 160,000 from merchants’ warehouses (HKTV, 2018b).

Leveraging HK’s high mobile penetration rate, HKTV has developed one-click purchasing features, personalized homepages, and filters to enhance mobile-optimized applications for customers (Chan *et al.*, 2020). The one-click purchasing function has simplified the order process by saving users’ payment details, and the personalized filters allow users to set their own filters like product price or producer when searching for goods.

HKTVMall also makes online payment easy. In April 2018, the first Open API partnership with Citibank to launch Citi Pay with Points on HKTVMall, and in June, it partnered with PayMe to launch seamless, secure mobile payments on the HKTVMall app. In July 2020, HKTVMall partners with Citibank to launch the first HKTVMall co-branded credit card. In October, HKTVMall launched eWallet, HKTVPay, to be used in all HKTVMall O2O shops and physical stores of merchant partners

In April 2021, HKTVexpress was launched. Operating 24 hours, HKTVexpress promises to deliver the ordered goods within one hour. The goods HKTVexpress delivers include food, grocery products, and fresh produce. The delivery fee for orders of HK\$200 or above is HK\$10. Otherwise, it is HK\$20. Customers can also choose to pick up their goods from HKTVMall's concept stores. HKTVexpress provides services from 70 shops, each serving customers within 2 kilometers (Magramo, 2021).

#### ***HKTV e-Commerce Fulfillment Co. Ltd., HKTV Logistics Network Co. Ltd., and HKTVexpress – The supply chain***

With HKTV e-Commerce Fulfillment Co. Ltd. and HKTV Logistics Network Co. Ltd., HKTVMall runs its own supply chain. HKTVMall's extensive fulfillment and logistics network have several automated warehouses, fulfillment centers, and delivery fleet, which are enabled and supported by big data and sophisticated systems. The company sources products, builds its own warehouses, automates the pick and pack process, designs and acquires its own delivery trucks, and designs and builds its apps, websites, and backend support systems.

Between 2015 and 2020, HKTVMall invested about HKD949.8 million in its supply chain to develop the cross-belt sorter system, add more delivery trucks, renovate fulfillment centers and enhance system capacity (HKTVMall, 2021). In 2016, HKTV expanded its warehouse and logistics center to Tsing Yi for an additional 144,000 square feet and launched the first Online Electronic Product Warehouse. In 2017, the company developed a robotic picking system and a conveying system in its Tsing Yi center to increase the fulfillment capacity. In 2018, the automated picking and warehousing system at Tsing Yi logistics center started full operation in March. In 2019, an automated picking & warehousing system at the logistics center of Tseung Kwan O headquarters commenced operation in March and later opened a new logistics center in Tuen Mun in July. In February 2020, a cross-belt sorter system commenced operation at the logistics center in Tuen Mun. At the same time, HKTVMall started working with individual drivers and companies to increase the number of trucks in operation, and the highest number of trucks available for use reaches 350 a day.

The fulfillment network and logistics systems have matured now and become an important part of HKTVMall. The systems not only handle and deliver customer orders for HKTVMall but also support third-party warehouse management and delivery services, mainly serving HKTVMall's merchant partners. The systems have enabled its merchants to focus on merchandising, digital marketing, and sales, strengthening the bonds and relationships between merchants and HKTVMall (HKTVM, 2021). Moreover, for HKTVMall, the more orders received, the lower the distribution costs because the higher the distribution density in each region, the shorter the delivery distance.

In 2021, HKTVexpress was launched by HKTVMall in partnership with Zeek, a smart logistic platform, to improve the capacity of its existing fulfillment system. Over the years, HKTVMall has established a loyal customer base, the expertise in logistics and delivery through learning by doing, developed the infrastructure based on automation and possessed a large amount of customer consumption data to enable big data analytics (Chan *et al.*, 2020). With years of experience in handling instant delivery, Zeek specializes in providing B2B Q-commerce solutions, using its own order and courier management system and a delivery fleet in HK. Therefore, HKTVMall and Zeek have complementary advantages to jointly deliver q-commerce.

#### ***Shoalter Technology Ltd. – A technological solution provider***

In November 2020, the company set up Shoalter Technology to benefit from the well-established online platform of HKTVMall. HKTVMall's platform covers every stage of customers' entire purchase journey, from placing purchase orders, arranging delivery through HKTVMall's self-operated logistics centers or its merchants for pick and pack to receiving goods enabled by its last-mile delivery. Particularly, as the only customer contact point, HKTVMall's logistics and delivery require very precise calculations and the full support of automated robotic systems. Building on HKTVMall's accumulated skills, know-how, and experiences, Shoalter provides technology solutions using robotic systems, cloud platforms, and big data to assist local and overseas companies in transforming traditional retail and e-commerce models to q-commerce models. By providing end-to-end e-commerce solutions locally and globally, Shoalter can share HKTVMall's unique knowledge, experiences, and technical skills in e-commerce.

The name, Shoalter, combines the word "Shoal," which means small fishes cooperate against external enemies, and the word "alter" means making the changes. Shoalter, therefore, indicates the unity of different retailers to change and to search for a new direction for the retail industry (HKTVM, 2021). HKTVMall believes that no single online shopping platform can monopolize the markets because every retailer has its own preposition to target customers of different types and age groups, and Shoalter's business partners will become the leader of their specific market segments to be mutually complementary to HKTVMall's leading position in an online supermarket (HKTVM, 2021). In HK, for example, Shoalter hopes to provide IT solutions to develop another two or three large-scale online shopping malls.

The company expects the actual return from Shoalter will be similar for HKTVmall to run its own online shopping mall. Besides the one-time implementation fee, Shoalter charges its business partners annual fees and sales turnover-based commission fees (HKTV, 2021). In December 2020, Shoalter entered into a definitive e-commerce solution agreement with an HK-based retail group. Shoalter provides hardware and software systems as a service to the retail group to support the setting up of its online shopping mall, which is expected to be launched in the third or fourth quarter of 2021 (HKTV, 2021).

### **The Pandamart Case**

The parent company of Pandamart is the Delivery Hero Group based in Berlin, Germany. Delivery Hero is one of the largest food and grocery delivery companies in the world, using online platforms to provide customers with on-demand food and grocery delivery services. In April 2021, the group saw a 400% year-on-year (YoY) growth of its q-commerce orders, processing a daily average of 400,000 orders globally. In Asia, this YoY growth even reached 450%. Pandamart accounts for nearly 30% of the Group's global cloud store operations (Foodpanda, 2021).

Delivery Hero firmly believes that technology is useful to meet the demands of more informed, proactive, and demanding customers in a highly digitalized world (Delivery Hero, 2019). They believe that urbanization and small households have led to rising demand for the fast delivery of goods in small quantities instead of purchasing many goods in large quantities at a cheaper price (Nierynck, 2020).

With the largest IT team operating from its headquarters in Berlin, Delivery Hero has strong and agile regional IT teams in all its segments. While leveraging the group's global platform, its local operations often rely on local IT teams to develop local solutions. The group normally invested about 5% of its revenue in R&D. In 2020, Delivery Hero's R&D expenses increased from €65.0 million in 2019 to reach €129.3 million, about 5.2% of its total revenue (Delivery Hero, 2020).

Delivery Hero's R&D investment focuses on developing innovative technologies to address specific issues, and the group has outsourced its IT and communications infrastructures to third parties, including SAP and Salesforce. Third parties provide a wide range of services to the Group, such as data host services, marketing, and payment processing. The group has also used licensed technologies provided by third parties. For example, the technology used to design the system for securely transmitting customers' personal data is third-party licensed authentication technologies (Delivery Hero, 2020).

Pandamart was first introduced to HK as the online grocery division of Foodpanda in late 2019 to meet the changing demand of lifestyles changes in HK. The decision was made based on Foodpanda's sales data, which showed that due to more single families, smaller living spaces, and busier lifestyles, there is an increasing demand for faster and more convenient delivery (Yuen, 2020). Unlike traditional supermarkets or e-commerce providers, Pandamart targets those customers who need urgent top-up services. Pandamart promises to deliver the goods to all customers in their markets within 25 minutes by the end of 2022, regardless of the size of the order (Foodpanda, 2021).

Pandamart benefits a lot from Delivery Hero and Foodpanda HK. Delivery Hero's technological strengths and Foodpanda's process mechanism in HK enable Pandamart to have a strong technology base to run its business. Pandamart and Foodpanda share the same infrastructure and operating system in HK. As in the first quarter of 2021, Foodpanda led HK's food delivery market with a 51% market share, and the majority of these users (43%) used Foodpanda exclusively (Measureable AI, 2021).

Pandamart is using Foodpanda's delivery team, which allows Pandamart to enter the new businesses at a lower cost without affecting Foodpanda's existing core businesses. The thermal storage bags Foodpanda has been using can hold up to 20 SKUs, which is similar to the typical basket size of Pandamart. The only difference is that Pandamart focuses on grocery and electronic stores while Foodpanda focuses on restaurants.

### **Customer Recommendation System**

Pandamart offers customers on-demand services with a wide variety of products. Customers can use its delivery app to get what they want 24 hours a day, seven days a week. Its service covers 80% of the total population in HK and aims to cover 100% by the end of 2020. The average delivery time is 25 minutes and as quick as within 15 minutes.

Pandamart offers more than 40,000 items online, including flowers, party supplies, pharmacy, cosmetics, snacks, electronics, fresh produce, home goods, and even alcoholic beverages. Pandamart is working directly with manufacturers and suppliers to offer a massive selection of brands. Customers can also use Pandamart's app to order a variety of products from local shops, including Circle K, Marks & Spencer, DS Groceries, and Muji. The fresh produce offered by Pandamart, such as dairy products, fruits, poultry, and vegetables, comes from small and medium enterprises and local grocers.

To improve customer experience, the company has collected big data and, based on data analysis to recommend meal and grocery products to customers even before customers make purchase decisions. It helps customer retention and future business growth by providing tailored customer service and detailed customer awareness. Additional revenues are generated from marketing services and cross-selling other products and services that match customer preferences (Delivery Hero, 2020). The ultimate goal set by Pandamart is to reach the point where they know exactly what each customer wants and when they want it. In December 2019 alone, the Delivery Hero Group possessed 22 billion data points following its data-driven approach. Big

data collection and analytics have simplified their ordering process and personalized their products. The order frequency increases after the company provides personalized recommendations, images of products, different payment options, convenient reorder facilities, and other subtle feature improvements (Delivery Hero, 2019).

### **Dark Stores (Dmarts)**

*The warehouses leverage our existing logistic network to provide efficiency and speed without the traditional geographical constraints. It also creates new distribution channels for small and local businesses with an additional window to sell their products.*

—Arun Makhija, CEO, Foodpanda Hong Kong (Yuen, 2020)

Dmarts, also called dark stores or cloud stores, are Pandamart's warehouses. Their sizes are between 4,000 and 5,000 square feet, smaller than traditional supermarkets' warehouses. Dmarts have enabled the company to provide quick last-mile delivery services for convenience and grocery products. A significant number of Dmarts opening in 2020 and the early half of 2021 have accelerated the fast growth of q-commerce in Delivery Hero globally (Delivery Hero, 2021).

All Dmarts rely heavily on technologies and data intelligence, including location selection, the products on the shelves in each store, and the arrangement of inventory to maximize picking efficiency. Using location intelligence and data trend insights, Pandamart has located Dmarts strategically to make grocery deliveries accessible to local communities. Demart's location has an optimized delivery radius and shortened order time, and its average delivery radius is 2.2 kilometers. Using two-wheel delivery fleets, such as bicycles and motorcycles, instead of trucks or vans, Pandamart is able to meet the 25-minute delivery service commitment (Nierynck, 2020).

There are 17 Dmarts in Hong Kong, including highly populated neighborhoods such as Central, Mong Kok, North Point, Tsuen Wan, and Tseng Kwan O. Though the rentals are higher than those outside the city center, Pandamart considers these centrally located Dmarts as a geographical advantage which enables the company to reach more customer faster and smoother (Nierynck, 2020). They also have some dark stores in non-prime locations, such as Chai Wan and Siu Sai Wan, paying lower warehouse rentals. Its location selection is aligned with Pandamart's sales strategies which emphasize the market demand, demographic distribution, and income levels of the residents.

Dmarts are purpose-built for deliveries only, not open to the public. The company only allows authorized Pandamart staff to access these dark stores to make sure a smooth and quick operation. Normally it takes fewer than five minutes for staff to pick and pack products in the dark stores. Interestingly, this minimum store patronage and a touch of products in the dark stores help Pandamart to ensure a high level of hygiene and safety during the COVID-19 pandemic. Operating around the clock, Dmart is a competitive advantage of Pandamart, but the handling costs like labor costs and utility costs can be high.

### **Logistics and Delivery**

Delivery Hero regards its existing logistics and delivery infrastructure as a competitive advantage, which enables the company to capture and satisfy customers' increasing demand for convenience (Delivery Hero, 2020). Logistics technologies, such as demand forecasting, fleet management, and route optimization, have reduced the cost per order and the delivery time as well as increased customer satisfaction and loyalty.

Delivery Hero is making considerable investments in delivery service, especially in the form of riders and delivery-related technology and capabilities (Delivery Hero, 2020). To improve unit economics and improve delivery efficiency, Delivery Hero has spent years building and refining its proprietary delivery area technologies. The technologies can not only define the delivery areas but also provide real-time optimization and delivery time estimates. The delivery time uses custom-built machine-learning algorithms based on the company's proprietary data. Its rider scheduling tool can continuously balance supply and demand and provide the riders with maximized flexibility. Using its proprietary data and algorithm, Foodpanda can estimate vendor preparation times based on the day of the week, the time of the day, and the size of the order to match the time a rider requires to reach the restaurant (Delivery Hero, 2019). This system can improve the food quality by reducing the time the food stays in the bag, which is also useful to assist Pandamart's operations.

In 2019, Delivery Hero developed and implemented its proprietary technology to provide innovative solutions, "Hurrier," to its restaurant partners. The solution not only enables restaurants to forecast demand and supply, manage the inventory and smoothen the delivery process but also improves the group's own delivery operations. Moreover, the company is able to provide live tracking or constant status updates to its customers, which has improved delivery accuracy (Delivery Hero, 2019).

Delivery Hero is also working to make use of innovative technology to improve operational efficiency to meet the growing demand for home delivery. In 2021, its autonomous robot will reach the testing stage in Sweden (Delivery Hero, 2021).

## **DISCUSSIONS**

In this section, we will discuss the motivations behind HKTVmall and Foodpanda's IT investments from economic, social, and technological perspectives. The IT applications mentioned in the discussion reflect the features of new digital technologies which can differentiate q-commerce from traditional grocery retailing business models.

### **Economic Factors**

Generally speaking, cost reduction and revenue generation are the two economic incentives behind HKTVmall and Pandamart's investments in new digital technologies.

First, both companies have invested in new digital technologies to improve the inventory process and lower the costs of inventory management. HKTVmall has used robotics in managing inventory in its warehouses to lower labor costs and improve the accuracy of inventory management. Pandamart has the system "Hurrier," developed by its parent company Delivery Hero, which can not only improve its own delivery operation but also help business partners to forecast supply and demand, manage the inventory and smoothen the delivery process.

Second, both companies have invested in new digital technologies to improve last-mile delivery and lower operational costs through partnerships. The use of new digital technologies makes collaboration with different business partnerships more convenient and efficient. As the number of orders increases, companies can optimize business operations and reduce costs by achieving an economy of scale. Besides home delivery, HKTVmall can use its concept stores and the retail network of its networks to offer pick-up services to its customers. HK's rent ranks among the highest in the world, and the average area of a traditional supermarket is thousands of square feet. An HKTVmall's concept store is about 200 square feet, which means the rental is a lot cheaper than a traditional supermarket. Moreover, HKTVmall has invested in developing an IT infrastructure for a number of years. When the number of orders increases, the company can lower the operational costs by automating the picking and packing and inventory management process and achieving the economy of scale.

Pandamart can save even more rentals because it does not have any physical stores. Different from HKTVmall, Pandamart is able to leverage Delivery Hero's technological innovations and HK Foodpanda's well-established network to lower operational costs and reduce the associated risks. Pandamart can share Foodpanda's infrastructure and rider team, reducing the cost of idle resources. While HKTVmall has developed its own infrastructure, Pandamart's outsourced its IT and communication infrastructure to third parties. Pandamart relies on individual technological innovations to achieve the economy of scale. For example, it has an optimized rider scheduling tool to balance supply and demand using big data analytics, which helps to shorten the delivery distance and time while giving its riders maximum flexibility.

Third, both companies used big data analytics to better understand customer preferences, which helps to accurately market products to the right target customers, thereby generating more revenue. For instance, Pandamart uses a customer recommendation system to make a recommendation to customers before they make a purchase decision. This not only targets the right customers but also promotes cross-selling.

### **Social Factors**

Changing market demographic characteristics and changing consumer behaviors can motivate companies to invest in new digital technologies.

First, both HKTVmall and Pandamart have observed changing demographic characteristics in HK and decided to invest in new digital technologies to realize q-commerce. HKTVmall made the decision to invest and change the retail patterns in HK in 2018 when the company discovered the downward trend of traditional retailing. In the case of Pandamart, the decision to enter into the HK market was made when Foodpanda's business indicated the general trend of more single-person households, smaller living spaces, and busier lifestyles in HK.

Second, changing customer behavior is a key motivation behind both companies' investment decisions on digital transformation. In recent years, an increasing number of customers have purchased grocery products from online platforms, which was further triggered by the outbreak of the COVID-19 pandemic to maintain social distancing. After the pandemic broke out, those customers who made their first online purchase discovered the benefits of convenience and relieved their security and privacy worries. They will tend to buy more online. As more customers buy from online platforms, companies have the opportunity to use big data analytics to better understand customer demands and improve customer experiences. With more customer data available, big data analytics can be applied to improve customer experience by providing personalized customer services. It is also helpful to accurately identify target customers with the right marketing schemes. For example, Pandamart is able to base on big data analytics to make purchase recommendations to customers before customers make the decision. HKTVmall relies on big data analytics to decide on the location of its concept stores.

### **Technological Factors**

Both companies have invested in new digital technologies to develop and sustain competitive advantages and minimize the risks of being imitated by their competitors. However, these two companies differ in their approaches to balancing IT infrastructure and innovation investments. In other words, HKTVmall's technological strength lies in its well-established IT

infrastructure to enable digital transformation, while Pandamart's technological strength lies in its proprietary technologies to meet the commitment of 25-minute fast delivery.

HKTVMall has adopted a staged approach, achieving radical digital transformation by making incremental, step-by-step changes. Now HKTVMall has developed a unique and comprehensive IT infrastructure, which is very difficult for other companies to imitate. Leveraging its well-established infrastructure and accumulated knowledge and experiences, HKTVMall not only runs its own operations but also set up a new company, Shoalter, to provide technological solutions to help e-commerce companies and retailers to go through digital transformation.

Pandamart has adopted a modular approach by creating dynamic, sustainable technologies through an evolving IT portfolio of temporary advantages. Instead of developing and maintaining its own IT infrastructure like HKTVMall, Delivery Hero, and hence Pandamart has outsourced its IT and telecommunication systems to third parties while focusing on developing its proprietary technologies. Delivery Hero has made a significant amount of investment in R&D to develop proprietary technologies to enable fast delivery. Its proprietary systems, such as Dmart's location intelligence, demand forecasting, fleet management, and route optimization, have enabled Pandamart to deliver the ordered goods to customers within half an hour, creating its competitive advantages.

Despite the differences in IT strengths, the availability and capabilities of new digital technologies have enabled both companies to achieve digital transformation. As a pioneer to build smart warehouses and logistics systems in HK, HKTVMall leverages big data analysis, using algorithms to help automate the entire e-commerce supply chain. Based on the customer data collection on their e-commerce website, the company has applied big data analytics to understand consumer behavior. This helps HKTVMall to have a more accurate target marketing strategy (Chen et al., 2020). Similarly, Pandamart uses big data analytics to decide the locations of Dmarts and to make product recommendations to customers before ordering, which helps to achieve q-commerce and improve customer experience.

### CONCLUSIONS

This paper analyses the driving forces behind two HK-based q-commerce companies, HKTVMall and Pandamart, to invest in digital transformation. To achieve digital transformation, HKTVMall adopts a staged approach by taking out incremental, step-by-step changes with the focus on developing a unique IT infrastructure, while Pandamart adopts a dynamic, modular approach by developing an evolving portfolio of temporary advantages with the focus on R&D to develop key function innovation. Through adopting different approaches and investing and using new digital technologies in different ways, both companies' engagement in digital transformation is driven by economic factors (cost reduction and revenue generation), social factors (changing demographic characteristics and changing customer behavior), and technological factors (proprietary technology advantages and new digital technology capabilities).

While our research has addressed the driving forces behind digital transformation, future studies can investigate how corporate performance differs if two companies have adopted different digital transformation approaches in the same industry. Moreover, since the nature of the industry is an important determinant of IT investment (Xue *et al.*, 2012) and the two cases we studied belong to the same industry, it is an interesting topic to study how digital transformation decisions are influenced by industry-specific factors.

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## E-data Utilization on National-Health Service Performance Assessment during Covid-19 in Bangladesh: New Evidence Using Data Envelopment Analysis (DEA) Technique

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### ABSTRACT

Making the entire world extremely nervous, more than the quarter of a year has gone past since the global breakout of deadly respiratory illness, named Coronavirus Disease-2019 (CoViD-19), over nine million people across the globe have already been infected with more than five percent death rate, and the number is still ascending at a tremendously frightening rate. This study has been driven to identify the adequacy and quality of responses from national health facilities in Bangladesh during this epidemic and discern the stimulates that influence the entire system. With an in-depth exercise of a nonparametric statistical method for proficiency weighting, namely the Data Envelopment Analysis (DEA) technique, the objective of this study of evaluating the thorough response and performance of the Bangladeshi National Health Service has been placed in efforts to be achieved. With the outcome, the method and operation of assessing the effective responsiveness, capability, and appropriate organization of the national health services (NHS) in Bangladesh during the ongoing COVID-19 pandemic have been revealed. It has also been specifically identified that this country's health system does not possess material mastery on input variables; neither do they have strong dominance over output variables. With a view to minimizing the expenditure, they should have decreased input variables alongside enhancing input resources thoroughly to deal with this pandemic with stringent governance. Direction and limitation of future research endeavors in this area may be indicated by this study. National responses across the globe can also be benchmarked.

*Keywords:* COVID-19, performance assessment, health service, DEA model.

### INTRODUCTION

In December 2019, the Coronavirus disease (COVID-19) patient was first time found in Wuhan, China and since then started outbreak globally (Kalhor et al., 2016). Until 08 May 2020, 22 countries have announced more than a thousand deaths: USA, France, Italy, United Kingdom, China, and So on. COVID-19 put a remarkable threat to National Health Service with a large scale of patients as well as uprising mortality rate (West et al., 2014). In Bangladesh, mostly every district got affected by COVID-19, with Dhaka and Narayanganj districts reporting confirmed cases at an alarming rate along with inadequate facilities and the governmental reluctance of infection testing of this lethally contagious disease at the initial stage.

Assuming the potential scale of COVID-19 patient number, the Bangladesh government and health ministry must take necessary actions to successfully control the rising caseload and ensure the standard quality of care as possible. The country of 160 million population has gained noticeable progress in uprising the life expectancy at birth (72 years). Based on DGHS' National Preparedness and Response Plan for Covid-19, only around 3% of GDP is spent on health care. However, the Government only allocated 1.02% of the current budget, and more than 70% is an out-of-pocket expenditure, the maximum in South Asia. Inequity, therefore, a devastated health care system is giving out. As can be seen in Table 1, out-of-pocket expenditures for Bangladesh are generally higher than those for the South Asia region as a whole.

**Table 1:** Out of pocket expenditure (as % of current health expenditure)

Indicator	Bangladesh	India	Pakistan	Sri Lanka	Nepal	Bhutan
Out of Pocket Expenditure (as % of current health expenditure)	73.9	65.1	60.2	49.8	57.8	13.3

Source: UNDP (Charnes, Cooper, & Rhodes, 1978)

Moreover, there is a severe shortage of health experts- doctors, nurses, and medical staff members. Bangladesh's doctor-to-patient ratio is the second-lowest in South Asia which is 5.26 per 10,000 people. A leading public health expert also noted that there was a poor distribution of workers in the health sector, with 78% of the Bangladeshi population living in rural areas while 70% of doctors were stationed in the city. On the policy aside, some key initiatives could be taken such as the budget allocation for the health sector should be increased significantly in the upcoming fiscal year of 2020-21 and should provide incentives and required facilities to selective private clinics and hospitals to obtain devoted covid-related management (Charnes et al., 1978).

Based on the previous studies, Chen and Soo (2010) adapted the DEA model to assess the performance efficiency of 11 Palestinian public hospitals in West Bank from 2010 through 2015, addressing a total of 66 observations. The hospitals were simulated to continue current resource consumption without declining the volume of the delivered service to increase potential savings. The DEA efficiency means score rises up to 4%, potential savings upturn to 14.5%. The increase in 1% outpatient-inpatient ratio (OPIPR) was marked/attributed to a 19.7% decline in predicted inefficiency level; *ceteris paribus*.

Kalhor et al. (2016) aimed this research to figure out the technical efficiency and its related factors in 110 Tehran general hospitals. Fifty-four hospitals were randomly chosen using DEA models. A descriptive analysis exhibited a significant relationship between hospital ownership, hospital type in terms of duty and specialization, the educational field of the chief executive officer, and technical efficiency, whereas no expressive relationship showed between the education level of hospital manager and technical efficiency.

West et al. (Ebenso & Otu, 2020) investigated a survey of workforce (doctors, nurse, and logistics staff) size on seriously ill Patients using the Multivariable, multilevel logistic regression method. The outcome positively claims that the survival chance of ill patients is associated with the availability of nursing and medical staff.

Plotlego et al. (Plotlego et al., 2010) employed DEA based productivity index on 21 non-teaching hospitals of Botswana to quantify sample hospitals' technical and scale efficiency and to evaluate changes in productivity over a period of three years (2006-2008). The outcomes show significant inefficiencies within the observation period and recommend outpatients numbers needed to be increased by the inefficient hospitals and inefficient staffs needed to be cut down in order to reach full efficiency. A recent review published between 1998 and 2008 focused on ICU patient outcomes and nurse staffing. On mortality rate studies, six reported association/fraternity with staffing (Cho, Hwang, & Kim, 2008; Stone et al., 2007; Person et al., 2004; Tarnow-Mordi et al., 2000) while five reported no association (Kiekkas et al., 2008; Metnitz et al., 2004; Dimick et al., 2001; Pronovost et al., 2001; Amaravadi et al., 2000). The summary reported that the association between ICUs' nursing staff and outcomes is similar to that noted in an analysis of the same relationship in ICU beds and logistics (West et al., 2014).

## DATA ANALYSIS & METHODOLOGY

The data for this study were drawn from the press release published by the Ministry of Health and Family Welfare in Bangladesh for the periods April 01, 2020, to April 21, 2020. DEA model has been employed in CoViD-19 Epidemic for the first time without any specific principles for the selection of input and output variables (Ramanathan, 2003). Eight input and two output variables have been used for efficiency evaluation, motivated by WHO's strategic objective for the prevention of pandemics (World Health Organization, 2020). Table 2 shows the summary statistics of input and output measures for NHS.

**Table 2:** Summary statistics of input and output variables

	Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
<b>Max</b>	5164	4539	29	103	94800	3625	1575	24	492	87
<b>Min</b>	141	4539	29	2	200	1123	1054	24	2	26
<b>Average</b>	1520.05	4539	29	41.95	37324.2	2646.33	1363.9	24	158.62	44.48
<b>SD</b>	1197.8	0	0	30.62	31321.3	1089.56	190.622	0	147.22	18.53

To realize the principal objective of the study, a DEA model and bootstrapped DEA model was applied using multiple inputs and outputs variables.

During the first stage, multiple inputs and outputs variables will be run using output-oriented, two most widely applied models, CCR (Charnes et al., 1978) and BCC (Banker, Charnes, & Cooper, 1984) model where the aim of the Decision-Making Unit (DMU) is the maximize outputs for a given level of inputs (Chen & Soo, 2010; Radhakrishnan, 2014; Zhu, 2014). The CCR model assumes a constant return to scale (CRS) while the BCC model assumes variable returns to scale (VRS) frontier (Debnath & Shankar, 2008; Radhakrishnan, 2014).

Consider  $n$  DMUs to be evaluated,  $DMU_j (j = 1, 2, \dots, n)$  that swallows the amounts  $X_m = \{X_{mi}\}$  of  $M$  different inputs

( $i = 1, 2, \dots, M$ ) and produces the amounts  $Y_i = \{Y_{li}\}$  of  $L$  different outputs ( $i = 1, 2, \dots, L$ ). The mathematical formulation of output-oriented efficiency of a particular DMU<sub>0</sub> under CCR linear programming model is presented as follows (Cooper, W.W., Seiford, L.M., & Tone, 2000):

$$\text{Max } \theta_i = \sum_{l=1}^L V_l Y_{li} \quad (1)$$

Subject to:

$$\begin{aligned} \sum_{m=1}^M u_m X_{mi} &= 1 \\ \sum_{l=1}^L V_l Y_{li} - \sum_{m=1}^M u_m X_{mi} &\leq 0 \\ u_l, u_m &\geq 0 \end{aligned}$$

Where  $u_l$  and  $u_m$  are the weights assigned to output  $l$  and input  $m$  respectively. The unknowns,  $u_l$  and  $u_m$ , are calculated as solutions to the linear programming problem. The term  $\sum_{l=1}^L V_l Y_{li}$  represents the virtual output (linear weighted sum of all outputs) and  $\sum_{m=1}^M u_m X_{mi}$  represents the virtual input (linear weighted sum of all inputs). The technical efficiency of the Health Care Service is defined as the ratio of virtual outputs to virtual inputs. Similarly, the mathematical formulation for an output-oriented BCC model is as follows (Banker et al., 1984):

$$\text{Max } \theta_i = \sum_{l=1}^L V_l Y_{li} - V_i \quad (2)$$

Subject to:

$$\begin{aligned} \sum_{m=1}^M u_m X_{mi} &= 1 \\ \sum_{l=1}^L V_l Y_{li} - \sum_{m=1}^M u_m X_{mi} - V_i &\leq 0 \\ u_l, u_m &\geq 0 \end{aligned}$$

Where  $u_l$  is the weight for output  $l$  and  $u_m$  is for input  $m$ . The difference between the formulation of the CCR and BCC model DEA linear programs is the addition of an intercept term  $V_i$ . A positive  $V_i$  denotes increasing returns to scale, a negative  $V_i$  denotes decreasing returns to scale and  $V_i = 0$  represents a constant return to scale.

At the second stage, the DEA efficiency scores will become the dependent variables, and the bootstrap algorithm will be executed to accurate efficiency estimates for bias (Hawdon, 2003).

## RESULTS

The sample consists of 21 DMUs groups, which comprises using variables from NHS of Bangladesh during CoVid19. Daily basis data for the date April 01, 2020, to April 21, 2020, were used in this study.

*Table 3* summarizes our results for the BCC and CCR models.

In light of the table, it is derived that the BCC and CCR model identifies technical efficiencies of 93% and 91% on average, respectively, which indicates that there is some feasible for improving the performance of NHS. Comparing the models, one can conclude that the BCC model has more efficient DMUs than the CCR model. Furthermore, the ratio of CCR and BCC scores can derive scale efficiency. If the scores are very close, we can conclude that the industry operates with constant-returns-to-scale technology. Considering the returns-to-scale (RTS) indicator, we can scale the inefficiency score. Our results show that there are eight variable-returns-to-scale (VRS) in the BCC model while 13 constant-returns-to-scale (CRS) in both BCC and CCR models. Among 21 days, 8 days were operated under increasing-returns-to-scale (IRS). Increasing returns to scale means the output increases by a large proportion than the increase in inputs during the production process (Banker, Cooper, Seiford, Thrall, & Zhu, 2004). On the other hand, constant returns to scale show increasing the number of inputs leads to an equivalent increase in the outputs.

**Table 3:** Summary statistics of DEA results

	BCC	CCR
Average Score	0.9341	0.9096
Standard Deviation	0.0998	0.1078
Maximum Efficiency Score	1	1
Minimum Efficiency Score	0.6583	0.6493
Number (and %) of efficient DMUs	11 (52%)	8 (38%)
Returns to scale		
# No. of increasing RTS	8	-
# No. of constant RTS	13	13
# No. of decreasing RTS	0	-

The study can conclude from the constant return to scale that NHS is more likely to have minimal economies or diseconomies of scale. However, even with constant returns to scale, NHS could still experience economies of scale if they can maintain lower average costs with increased output.

From the second stage bootstrap DEA result shows in

Table 4. In order to bootstrap, the researcher used VRS efficiency scores. The mean value of bootstrap and the original sample is 0.9342 and 0.9341, respectively.

**Table 4** Descriptive statistics of bootstrap sample and original sample

Bootstrap Sample					Original Sample				
Obs.	Mean	Std. Dev.	95% Conf.	Interval	Obs.	Mean	Std. Dev.	95% Conf.	Interval
2,000	0.9342	0.0005	0.9332	0.9351	21	0.9341	0.0218	0.8887	0.9795

Source: Authors' calculation (Stata v16)

**Table 5** Efficiency score & projection model (BCC-Output oriented)

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
DMU1	1	1	Weight	0.94	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	1.00
			Projection	157.00	4539.00	29.00	9.00	5180.00	1123.00	1575.00	24.00	3.00	26.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU1	1.00								
DMU2	1	1	Weight	0.00	0.00	0.00	0.63	0.00	0.37	0.00	0.00	0.00	1.00
			Projection	141.00	4539.00	29.00	5.00	13600.00	1123.00	1575.00	24.00	2.00	26.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU2	1.00								
DMU3	0.94	14	Weight	0.23	0.00	0.00	0.00	0.03	0.81	0.00	0.00	0.00	1.00
			Projection	203.00	4539.00	29.00	7.34	13600.00	1123.00	1575.00	24.00	6.35	27.79
			Diff.(%)	0.00	0.00	0.00	-47.58	0.00	0.00	0.00	0.00	27.08	6.88
			Reference( $\lambda$ )	DMU1	0.27	DMU2	0.48	DMU5	0.26				
DMU4	0.91	15	Weight	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.29	0.00	1.00
			Projection	367.00	4539.00	29.00	10.00	22344.50	1123.00	1575.00	24.00	18.00	33.00
			Diff.(%)	-15.44	0.00	0.00	-44.44	0.00	0.00	0.00	0.00	100.00	10.00
			Reference( $\lambda$ )	DMU5	1.00								
DMU5	1	1	Weight	0.34	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	1.00
			Projection	367.00	4539.00	29.00	10.00	22344.50	1123.00	1575.00	24.00	18.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU5	1.00								

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
DMU6	1	1	Weight	0.00	0.00	0.00	0.00	0.16	0.84	0.00	0.00	0.02	0.98
			Projection	468.00	4539.00	29.00	23.00	23835.00	1123.00	1575.00	24.00	35.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU6	1.00								
DMU7	0.85	17	Weight	0.00	0.27	0.00	0.00	0.00	0.91	0.00	0.00	0.00	1.00
			Projection	640.00	4539.00	29.00	18.27	24817.43	1385.00	1547.67	24.00	61.56	38.65
			Diff.(%)	-5.74	0.00	0.00	-39.09	-7.12	0.00	-1.74	0.00	50.15	17.14
			Reference( $\lambda$ )	DMU5	0.90	DMU21	0.11						
DMU8	0.90	16	Weight	0.00	0.36	0.00	0.53	0.21	0.00	0.00	0.00	0.00	1.00
			Projection	684.81	4539.00	29.00	16.00	8880.00	1787.25	1465.01	24.00	97.51	36.61
			Diff.(%)	-86.74	0.00	0.00	0.00	0.00	-28.08	-6.98	0.00	80.58	10.95
			Reference( $\lambda$ )	DMU1	0.71	DMU9	0.13	DMU20	0.17				
DMU9	1	1	Weight	0.00	0.00	0.00	0.06	0.00	0.35	0.00	0.60	0.00	1.00
			Projection	905.00	4539.00	29.00	2.00	23870.00	3085.00	1054.00	24.00	112.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU9	1.00								
DMU10	0.98	13	Weight	0.00	0.00	0.00	0.00	0.10	0.00	6.53	0.00	0.00	1.00
			Projection	962.61	4538.95	29.00	7.96	31500.00	3084.99	1054.00	24.00	115.59	33.80
			Diff.(%)	-18.70	0.00	0.00	-66.85	0.00	0.00	0.00	0.00	22.96	2.41
			Reference( $\lambda$ )	DMU9	0.87	DMU12	0.13						
DMU11	1	1	Weight	0.63	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	1.00

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
			Projection	954.00	4538.95	29.00	35.00	70697.98	3084.94	1054.00	24.00	58.00	36.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
			Reference( $\lambda$ )	DMU11	1.00								
DMU12	1	1	Weight	0.49	0.00	0.00	0.00	0.00	0.00	3.35	0.00	0.13	0.87
			Projection	1340.00	4538.95	29.00	47.00	81544.82	3084.99	1054.00	24.00	139.00	39.00
			Diff.(%)	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU12	1.00								
DMU13	0.75	20	Weight	1.00	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.11	0.89
			Projection	1570.00	4538.95	29.00	32.63	25243.36	2762.90	1314.00	24.00	242.27	55.91
			Diff.(%)	0.00	0.00	0.00	-61.16	-72.53	-23.78	0.00	0.00	33.11	33.11
			Reference( $\lambda$ )	DMU5	0.28	DMU9	0.15	DMU11	0.14	DMU20	0.43		
DMU14	0.66	21	Weight	1.19	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.12	0.88
			Projection	1905.00	4538.95	29.00	36.38	17431.11	3005.03	1314.00	24.00	317.47	63.80
			Diff.(%)	0.00	0.00	0.00	-59.12	-81.61	-17.10	0.00	0.00	51.90	51.90
			Reference( $\lambda$ )	DMU5	0.20	DMU9	0.20	DMU11	0.01	DMU20	0.59		
DMU15	0.81	19	Weight	0.85	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	1.00
			Projection	1740.00	4538.95	29.00	40.09	29491.28	2879.71	1314.00	24.00	269.30	60.23
			Diff.(%)	0.00	0.00	0.00	-43.54	-59.15	-20.56	0.00	0.00	22.97	22.91
			Reference( $\lambda$ )	DMU5	0.25	DMU11	0.25	DMU20	0.51				
DMU16	0.99	12	Weight	0.89	0.00	0.00	0.19	0.00	0.00	0.00	0.00	1.00	0.00
			Projection	2019.00	4538.95	29.00	37.00	16106.67	3248.05	1265.40	24.00	341.96	65.20

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
			Diff.(%)	0.00	0.00	0.00	0.00	-82.53	-10.40	-3.70	0.00	0.28	33.06
			Reference( $\lambda$ )	DMU2	0.09	DMU9	0.28	DMU20	0.63				
DMU17	0.82	18	Weight	0.92	0.00	0.00	0.00	0.01	0.00	0.57	0.00	0.00	1.00
			Projection	2190.00	4538.95	29.00	45.00	18800.00	3205.11	1314.00	24.00	370.59	70.82
			Diff.(%)	0.00	0.00	0.00	-56.31	0.00	-11.58	0.00	0.00	39.32	22.10
			Reference( $\lambda$ )	DMU5	0.14	DMU9	0.08	DMU11	0.06	DMU20	0.72		
DMU18	1	1	Weight	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
			Projection	2114.00	4539.00	29.00	66.00	200.00	3625.00	1314.00	24.00	306.00	66.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU18	1.00								
DMU19	1	1	Weight	0.00	0.00	0.00	0.66	0.30	0.00	0.24	0.00	0.00	1.00
			Projection	2633.88	4538.95	29.00	52.00	10605.00	3624.84	1314.00	24.00	312.05	75.00
			Diff.(%)	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
			Reference( $\lambda$ )	DMU19	1.00								
DMU20	1	1	Weight	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.15
			Projection	2779.00	4539.00	29.00	57.00	13050.00	3625.00	1314.00	24.00	492.00	85.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU20	1.00								
DMU21	1	1	Weight	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00
			Projection	2974.00	4539.00	29.00	89.00	45960.00	3625.00	1314.00	24.00	434.00	87.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DMU	Score	Rank	Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
			Reference( $\lambda$ )	DMU21	1.00							

Source: Authors' calculation (DEA-Solver LV8.0)

**Table 6** Efficiency Score &Projection Model (CCR-Output Oriented)

DMU	Score	Rank	Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered	
DMU1	1	1	Weight	0.96	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.09	0.91
			Projection	157.00	4539.00	29.00	9.00	5180.00	1123.00	1575.00	24.00	3.00	26.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	1575.00	24.00	0.00	0.00
			Reference( $\lambda$ )	DMU1	1								
DMU2	1	1	Weight	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
			Projection	141.00	4539.00	29.00	5.00	13600.00	1123.00	1575.00	24.00	2.00	26.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU2	1								
DMU3	0.94	11	Weight	0.23	0.00	0.00	0.00	0.03	0.81	0.00	0.00	0.00	1.00
			Projection	203.00	4539.00	29.00	7.34	13600.00	1123.00	1575.00	24.00	6.35	27.79
			Diff.(%)	0.00	0.00	0.00	-47.58	0.00	0.00	0.00	0.00	27.08	6.88
			Reference( $\lambda$ )	DMU1	0.265	DMU2	0.479	DMU5	0.256				
DMU4	0.91	13	Weight	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	1.00
			Projection	367.00	4539.00	29.00	10.00	22344.50	1123.00	1575.00	24.00	18.00	33.00
			Diff.(%)	-15.44	0.00	0.00	-44.44	0.00	0.00	0.00	0.00	100.00	10.00
			Reference( $\lambda$ )	DMU5	1								

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
DMU5	1	1	Weight	0.24	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
			Projection	367.00	4539.00	29.00	10.00	22344.50	1123.00	1575.00	24.00	18.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU5	1								
DMU6	1	1	Weight	0.27	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.12	0.88
			Projection	468.00	4539.00	29.00	23.00	23835.00	1123.00	1575.00	24.00	35.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU6	1								
DMU7	0.85	15	Weight	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.27	0.00	1.00
			Projection	679.00	4539.00	29.00	23.29	25393.04	1385.00	1547.67	24.00	68.13	38.65
			Diff.(%)	0.00	0.00	0.00	-22.36	-4.97	0.00	-1.74	0.00	66.16	17.14
			Reference( $\lambda$ )	DMU5	0.509	DMU6	0.386	DMU21	0.105				
DMU8	0.90	14	Weight	0.00	0.36	0.00	0.53	0.21	0.00	0.00	0.00	0.00	1.00
			Projection	684.81	4539.00	29.00	16.00	8880.00	1787.25	1465.01	24.00	97.51	36.61
			Diff.(%)	-86.74	0.00	0.00	0.00	0.00	-28.08	-6.98	0.00	80.58	10.95
			Reference( $\lambda$ )	DMU1	0.707	DMU9	0.129	DMU20	0.165				
DMU9	1	1	Weight	0.97	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.72	0.28
			Projection	905.00	4539.00	29.00	2.00	23870.00	3085.00	1054.00	24.00	112.00	33.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU9	1								
DMU10	0.76	19	Weight	0.66	0.00	0.00	0.18	0.00	0.00	0.48	0.00	1.00	

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
DMU11	0.93	12	Projection	1184.00	3408.15	21.77	24.00	13512.60	1877.47	1054.00	18.02	191.27	43.60
			Diff.(%)	0.00	-24.91	-24.91	0.00	-57.10	-39.14	0.00	-24.91	103.48	32.13
			Reference( $\lambda$ )	DMU5	0.323	DMU9	0.065	DMU20	0.362				
			Weight	0.62	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	1.00
			Projection	954.00	3253.01	20.78	20.63	13351.20	1521.59	1054.00	17.20	148.69	38.55
DMU12	0.82	16	Diff.(%)	0.00	-28.33	-28.33	-41.05	-81.12	-50.68	0.00	-28.33	156.36	7.08
			Reference( $\lambda$ )	DMU5	0.43	DMU20	0.286						
			Weight	0.80	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	1.00
			Projection	1340.00	3370.42	21.53	28.23	12478.35	1941.20	1054.00	17.82	223.15	47.52
			Diff.(%)	0.00	-25.75	-25.75	-39.94	-84.70	-37.08	0.00	-25.75	60.54	21.84
DMU13	0.74	20	Reference( $\lambda$ )	DMU5	0.3	DMU20	0.443						
			Weight	0.87	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	1.00
			Projection	1570.00	4171.25	26.65	33.21	15783.87	2310.75	1314.00	22.06	258.80	56.90
			Diff.(%)	0.00	-8.10	-8.10	-60.46	-82.83	-36.26	0.00	-8.10	42.20	35.48
			Reference( $\lambda$ )	DMU5	0.408	DMU20	0.511						
DMU14	0.65	21	Weight	1.05	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	1.00
			Projection	1905.00	4273.15	27.30	39.80	15026.35	2674.91	1314.00	22.59	323.41	64.69
			Diff.(%)	0.00	-5.86	-5.86	-55.28	-84.15	-26.21	0.00	-5.86	54.74	54.02
			Reference( $\lambda$ )	DMU5	0.295	DMU20	0.647						
			Weight	0.83	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	1.00
DMU15	0.81	18	Projection	1740.00	4222.96	26.98	36.56	15399.46	2495.55	1314.00	22.33	291.59	60.85

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
			Diff.(%)	0.00	-6.96	-6.96	-48.51	-78.67	-31.16	0.00	-6.96	33.15	24.19
			Reference( $\lambda$ )	DMU5	0.351	DMU20	0.58						
DMU16	0.99	10	Weight	0.69	0.00	0.00	0.32	0.00	0.00	0.00	0.00	1.00	0.00
			Projection	2019.00	4112.98	26.28	37.00	14707.23	3140.93	1121.42	21.75	344.60	63.17
			Diff.(%)	0.00	-9.39	-9.39	0.00	-84.04	-13.35	-14.66	-9.39	1.06	28.92
			Reference( $\lambda$ )	DMU9	0.266	DMU20	0.64						
DMU17	0.81	17	Weight	0.88	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	1.00
			Projection	2190.00	4359.84	27.86	45.41	14381.89	2984.72	1314.00	23.05	378.39	71.31
			Diff.(%)	0.00	-3.95	-3.95	-55.91	-23.50	-17.66	0.00	-3.95	42.25	22.95
			Reference( $\lambda$ )	DMU5	0.199	DMU20	0.762						
DMU18	1	1	Weight	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
			Projection	2114.00	4539.00	29.00	66.00	200.00	3625.00	1314.00	24.00	306.00	66.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU18	1								
DMU19	0.99	9	Weight	0.00	0.00	0.00	0.63	0.30	0.00	0.08	0.00	0.00	1.00
			Projection	2387.34	4448.20	28.42	52.00	10605.00	3300.50	1314.00	23.52	412.77	75.30
			Diff.(%)	-9.37	-2.00	-2.00	0.00	0.00	-8.95	0.00	-2.00	32.30	0.40
			Reference( $\lambda$ )	DMU1	0.101	DMU18	0.108	DMU20	0.771				
DMU20	1	1	Weight	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.15
			Projection	2779.00	4539.00	29.00	57.00	13050.00	3625.00	1314.00	24.00	492.00	85.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DMU	Score	Rank		Total Test	Beds	ICU Bed	Isolation	Logistic	Doctor	Nurse	Ventilator	Infected	Recovered
			Reference( $\lambda$ )	DMU20	1								
DMU21	1	1	Weight	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
			Projection	2974.00	4539.00	29.00	89.00	45960.00	3625.00	1314.00	24.00	434.00	87.00
			Diff.(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Reference( $\lambda$ )	DMU21	1								

Source: Authors' calculation (DEA-Solver LV8.0)

## DISCUSSIONS

**Table 5** and **Table 6** provide both efficiency score and projection model for output-oriented BCC model and CCR model, respectively.

From **Table 5**, one can identify from the weight that DMU1 is efficient because they might perform well at beds, ICU beds, isolations, logistics, doctors, nurses, and ventilators as an input variable. On the other hand, DMU1 was doing well to identify the infected patients, as well as NHS, is producing output. Additionally, DMU1 still has the opportunity to provide more effort on tests and logistics to keep their efficiency level and to be more efficient. Consecutively in succession, it would be ascertainable for other DMUs those fall into the efficient frontier line and also have rank 1. DMU16 did not fall into the efficient frontier line, while as an inefficient DMU, it ranked at 12. In order to benchmark DMU16 on the frontier, NHS can provide their effort on total test and isolation to detect maximum infected patients. The explanation for the CCR model can also be established as per BCC, thereby achieving outcomes as well.

From the projection model, it is observed that DMU13 (BCC model) should increase each of its outputs, including the number of infected and recovered, by 25% and 17%, respectively, to reach the efficient frontier. Moreover, DMU13 has to wane its input resources, including isolation by 61.16%, logistic by 72.53%, doctor by 23.78%, to achieve desired each of its output such as the number of infected 242 and number of recovered 55. CCR model can also be demonstrated in the same way for DMU17. According to the projection model, it has been suggested that NHS should focus on lessening of input variables to reduce the cost. In the meantime, it is required to increase input resources to control the pandemic. In this study, it has happened maybe because NHS could not use input resources properly to get more output. So, NHS does not have much control over either input variable or output variable. The projection model of both BCC and CCR can also be identified in the same way as described above.

In the light of the bootstrap result, we can see the bootstrap mean almost equal to the sample mean. Bootstrap mean and sample mean should be theoretically equal to the sample mean; otherwise, sample bias would not be possible to reduce (Hall, 2013).

## CONCLUSION

This research was motivated by mortality which may rise as hospitals become overwhelmed and have inadequate resources than necessary. Throughout the study, NHS of Bangladesh has not had much control on input variables because there are 13 constant RTS while increasing RTS and decreasing RTS are 8 and 0, respectively. Moreover, efficient scores also show the same results while there are different levels of efficient scores, which is not continuously improving for the different DMUs.

The importance of selecting the appropriate benchmarking or reference set has also been focused on by this paper when making recommendations for improving inefficient DMUs. This study identifies that NHS could not use input resources properly to achieve more output. Therefore input resources need to be increased. As a result, the production cost is higher, which might prevent the DMUs from becoming efficient. So, NHS has much control neither on input variable nor on output variable.

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## APPENDIX

### Description of the Variables

Variable	Definition	Data Source
<b>Input</b>		
Total Test	Total number of CoViD-19 tests for per day basis	DGHS
Beds	The total number of beds are arranged both for isolation and treatment purpose	DGHS
ICU Bed	Total number of ICU beds	DGHS
Isolation	Total number of isolated at medical center	DGHS
Logistic	The total number of non-pharmaceutical supplies had been distributed, e.g., surgical gloves, hexisol, personal protection equipment, mask, eye protector, etc.	DGHS
Doctor	The total number of doctors had been employed to serve patients	DGHS
Nurse	The total number of doctors had been employed to serve patients	DGHS
Ventilator	The total number of ventilators are used for CoViD-19 patients.	DGHS
<b>Outputs</b>		
Infected	Accumulated infected found after testing	DGHS
Recovered	Accumulated recovered after treatment	DGHS

## **Effect of Leverage on Firm Value and How the Contextual Variables Affect This Relationship: A Case of Pakistan**

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### **ABSTRACT**

The purpose of this study is to investigate capital structure in the Pakistani corporate sector in light of the interest rate gap with other countries and emerging Islamic banking in the country. The study investigates the effect of leverage on firm value (Tobin's Q) and how other variables impact this relationship. The study used the System-GMM-Fixed effect model for linear analysis and fixed effect panel threshold regression model by Hansen (1999) for quadratic analysis using data from non-financial firms listed on the Pakistan Stock exchange for the period 2005 to 2019. The results show that there is a negative relation between leverage and the value of the firm. In contrast, debt and non-debt tax shields have a positive relationship with the value of the firm. The study also found that there is quadratic nature of leverage with the value of the firm. The study supports Trade-off theory, pecking order theory, while it doesn't support agency theory.

*Keywords:* Leverage, firm value, optimal capital structure, panel threshold analysis.

### **INTRODUCTION**

Firms are concerned with their financing resources if it is for normal operations or specific projects. The source can be debt or equity or the mix of both or maybe some internal sources. The second thing that comes into mind is the cost of these funds, which the firms want to get through for generating capital, and then the pros and then the advantages and disadvantages of the cost. Capital structure decision is one of the important decisions made by financial managers, especially in the area of corporate finance. It provides a base for many other decisions like project financing, dividend policy, issue of long-term securities, financing of mergers, buyouts, and so on.

Managers have several objectives, like maximizing the wealth of shareholders, value of a firm, lowering the cost of capital, and diverting bankruptcy agency problems, etc. In 1958, Modigliani and Miller (1958) presented an irrelevance proposition which states that capital structure does not affect firm value under restrictive assumptions, which means the firm value is irrelevant to capital structure or financing decision. After that, an intensive investigation was made on the topic of capital structure (the mix of debt and equity capital). The Modigliani-Miller (M&M) proposition is the first theory about capital structure. In addition to the original Modigliani and Miller paper, other important contributions were made, which include a study by Stiglitz (1969) and many more. The second irrelevance proposition states that "given a firm's investment policy, the dividend payout a firm chooses to follow will affect neither the current price of its shares nor the total return to its shareholders" (Miller and Modigliani, 1961).

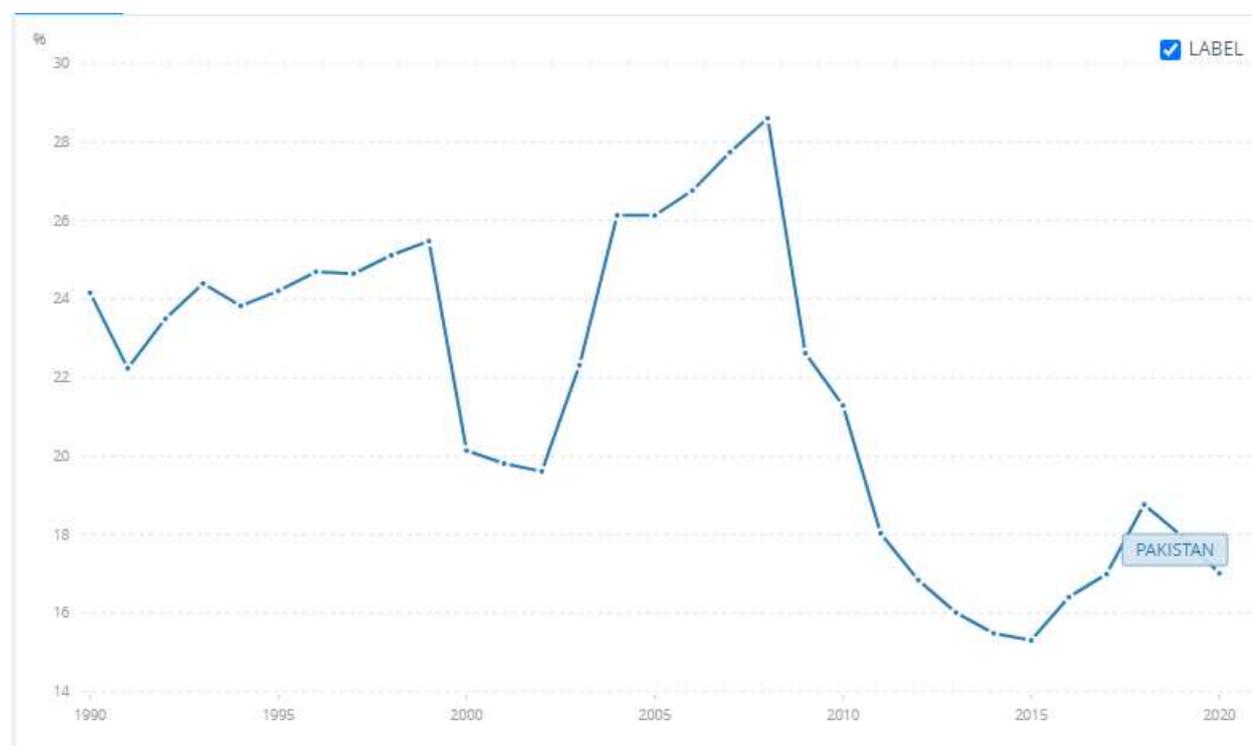
In 1963 M&M proposed tradeoff theory which differentiates the value of a firm on the basis of leverage means the value of a leveraged firm and the value of the unleveraged firm. According to this theory adding more debt will increase the interest tax shield. The interest expense can reduce the amount of tax the firm has to pay. While they also consider the presence of bankruptcy cost as a result of increased debt. Jensen and Meckling (1976) argued that there is an optimal level of debt associated with minimum agency cost, as such type of conflicts leads to agency problem and further to agency cost, and is called "Agency Theory." Jensen (1986) argued that debt may reduce the agency cost by reducing the availability of free cash flow to the managers. In 1984, Myers and Majluf presented "Pecking order theory" The pecking order theory considers choosing the internal or external source of finance to fund their assets or projects, i.e., first internal, then external. The signaling theory (Ross 1977; Heinkel, 1982) states that firms with favorable prospects with raise new funds through debt financing while firms with unfavorable prospects will try to raise new capital through equity financing. Ross (1977) shows how debt could be used as a costly signal to separate the good from the bad firms. Another theory in capital structure is "The market timing theory," by Baker and Wurgler (2002), which says that firms issue new stock when their share price is overvalued, and they repurchase their shares when their share price is undervalued. According to Fama (1980), managers prefer less leverage financing because they want to minimize the risk and to protect their undiversified human capital. Recently many studies argued that macroeconomic factors impact the firm capital structure decision, i.e., inflation rate, etc

This study will focus on macroeconomic factors and the corporate environment and how they affect the capital structure decisions in the Pakistani industry and then the value of the firm. It will investigate the level of leverage and relation of leverage with firm performance. The main motivation behind this study is Cheng and Tzeng (2014), who argue that leverage

has a positive relationship with firm value in a low-interest economy (Taiwan), but we are going to see what will happen if there is a high-interest rate and cost of debt is high. The reason we choose the Pakistani sector is the nature and condition of the Pakistani banking sector and corporate environment. In the last two decades interest rate in Pakistan has risen too much; the average interest rate for lending is 11.5% from the Year 2005-2019. At the same time, the interest rate in Taiwan drops from 8.7% to 3.8% from 1991 up to 2009. On the other hand, after 2001, Islamic banking in Pakistan has emerged very fast, and according to recent reports, the Islamic banking industry in Pakistan reported 29% growth for the year 2020, which is the highest in history, while the overall banking sector recorded 14.5% growth in the same year. Along with the high cost of debt, the banks in Pakistan are reluctant to provide long-term debts due to immature security and collateral system, that's why all these hurdles make debt very costly for Pakistani firms, and many businesses are going for partnership and lease type loans under Islamic finance. World Bank data shows a huge decrease in credit to Pakistan's private sector by banks in the last two decades. Figure 1 shows a graphical representation of the lending data for Pakistan, while figure 2 & 3 shows interest rate historical data for Taiwan and Pakistan.

Another factor that makes this study interesting is the tax system of the corporate environment of Pakistan. Many firms in Pakistan are controlled by families or groups of people who have stakes in multiple businesses. Also, the tax system in Pakistan is not much developed. People are escaping from tax-paying, especially the industries, and there are many incentives and tax exemptions given to different sectors by the government.

Keeping in mind all these problems, our study analyzed the leverage level of all the non-financial firms in Pakistan and investigated how the debt impact value of firm and how the other factors influence this relationship.



Source: World Bank Data

Figure1. Domestic credit to the private sector as percent (%) of GDP in Pakistan (1990-2020).

### LITERATURE REVIEW

After the emergence of many capital structure theories like M&M's (1958) proposition theory, Tradeoff theory, pecking order theory, and market timing theory, etc., many researchers conducted studies to check the practical implications of these theories. M&M's (1958) proposition theory states that the firm value and weighted average cost of capital (WACC) are irrelevant to the financial structure of the firm other things remain constant. Jermias (2008) found that the use of debt financing not only provides a tax shield to the firm but it also improves efficiency because of restrictive covenants imposed by the lenders. In comparison, Phillips and Sipahioglu (2004) and Qureshi (2007) found an inverse association between the level of debt and firm value.

After that, M&M 1963 considered the tax shield effect and modified their original theory (Tradeoff theory). They illustrate that when corporate tax laws allow the deductibility of interest payments, then the market value of the firm will be increasing as a response to leverage. Some studies argue that the use of debt increase as a result of high marginal tax rates (Mackie-Mason, 1990, Graham 1996). Graham 2000, using financial statements of firms, argued that mean corporate tax benefits to firm as a result of debt interest shield is 10% of firm value.

Miller (1977) also considered leverage as a function of increasing firm value. But both the previous theories do not consider the bankruptcy cost, which is the negative side of debt. Wruck (1990) argued as a situation when a firm's operating cash-flows are not sufficient to meet the current obligations, and the firm is forced to take corrective measures. Stiglitz (1972) and Kim (1978) stated that when advantages from marginal tax shield equal marginal bankruptcy costs, this is called the optimal level, where the firm value reaches its maximum level. Altman (1984) and Warner (1977) find that the bankruptcy costs and financing decision, they argued that using debt financing can create direct and indirect bankruptcy costs. Therefore, Bankruptcy costs may be one of the hurdles affecting the level of financing decision.

Frank and Goyal, 2009 argued that there is no optimal capital level. The firm chooses the source of financing in view of the cost of financing and access, i.e., internal funds, debt, and equity. Jensen (1986) proposed the Free cash flow theory and argued that debt might reduce the agency cost by reducing the availability of free cash flow to the managers.

To get a deep view of the sprawling research field, two ways of thinking can be explored. First, one can use the pecking order theory, where the company is supposed to choose internal funds before external financing without planning for any predetermined debt-to-equity ratio. Secondly, one can follow a trade-off framework to explain the firm's choice of capital structure.

Further research leads to acceptance and rejection of these two main theories (Fama & French, 2002; Ozkan, 2001). In the presence of information asymmetry or imperfections such as recapitalization costs, deviations from the optimum may not be perfectly adjusted for in each period, as stated in static trade-off theory (Fischer et al., 1989).

Some authors argued that some internal factors matter a lot in deciding capital structure. Factors that are considered as the most important are profitability, the tangibility of assets, size, growth, depreciation, and earnings volatility (Frank & Goyal 2009). De Jong, Kabir, and Nguyen, (2008), by studying firms' specific characteristics across 42 countries, found that firm-specific determinants of leverage differ across countries, and also there is an indirect impact because country-specific factors also influence the roles of firm-specific determinants of leverage. Some studies argued that both country and industry are significant factors influencing capital structure in Asia (Aggarwal, 1990; Krishnan & Moyer, 1997).

Further studies argued that some internal factors or economic factors affect the financing decisions (Mackie-Mason, 1990, Graham 1996) argued that leverage increase with an increase in the tax rate, which can benefit in increasing firm value. (Barton & Gordon, 1988; Bauer, 2004) argued that profitability can lead to change in future financing decisions. At the same time, Bokpin (2009) found that macro-economic factors can affect firm financing decisions. Bhamra, Fisher, and Kuehn (2011) claim that monetary policy influences corporate scenarios through its impact on inflation and inflation expectations. In comparison, some studies found that stock return affects the capital structure of a firm (Hovakimian, Opler, and Titman, 2001) claim that stock volatility affects the choice of debt and equity by managers.

Countries with strong and vital financial systems are likely to provide greater access to the financial resources needed for innovation and investments (Edquist 2005; Huang & Xu 1999) as compared to countries that are not so well equipped with resources and infrastructure. These Sources of inputs include banks, stock markets, and venture capital. While stock markets provide access to equity for established firms, banks serve as a source of funding for private businesses and small firms from established sectors (Levine & Zervos 1998). Selecting equity or debt financing depends on corporate structure and country-specific economic factors. The main factors are interest rate and tax.

There are several studies conducted on the country level in Pakistan, like Raza (2013) argued that there is a negative relation between leverage and firm performance, for textile industry leverage ratio is high, and on average, profitability is negative due to high cost of long-term debt. Scholars (Raza, 2013; Farooq & Masood, 2016) found that in the cement sector, there is a positive relationship between leverage and firm performance. Other studies (Raza, 2013; Farooq & Masood, 2016; Khan, 2012) argued that there positive/negative relationship between leverage and firm value in different sectors of the Pakistani industry. Shah, A & Khan, Safi. (2007) found that there were significant industry effects, and their studies agreed with trade off theory & pecking order theory. There are some other famous studies on the capital structure design and decisions in Pakistani industry (e.g., Mumtaz et al., 2013; Rafique, 2011; Shah & Hijazi, 2004; Sheikh & Wang, 2011; Fareed, et al., 2014), but they all focus on small periods and specific sectors, and some include era before 2000, while this study will focus on more detailed period and will cover all sectors from the industry as well as will focus on industry wise leverage position.

### HYPOTHESIS

On the basis of the above discussion, our proposed hypothesis will be as under;

H1= Leverage will increase the firm value if the financial quality is better

H2: Debt-Tax shield will increase the value of the firm if bankruptcy cost is low

H3: Non-Debt-Tax shield will have a positive impact on firm value of financial quality is better

H4: High free cash flow will have a negative impact on the value of the firm

H5: Profitability will positively impact the value of the firm.

H6: Leverage will positively impact the value of the firm if the growth opportunities are higher;

H7: Dividend payment will have a positive impact on firm value

H8: A firm with more liquid assets will have a higher value

H9: Firm with more tangible assets will have high debt in their capital structure, which will lead to a higher value of the firm

H10: There exists an optimal capital structure while using debt financing

### DATA AND METHODOLOGY

The study uses data from companies on the Karachi stock exchange (Pakistan). The sample period consists of fifteen years from 2005 to 2009. The data was collected from reports published by the State bank of Pakistan.

This study will use the Generalized Method of Moment (GMM) with fixed effects to estimate our variables with one step lag of dependent variable as an independent variable in the model for our linear sturdy. And next, we will use Hansen’s (1999, 2000) fixed effect panel threshold regression model for threshold study, with an advanced tool proposed by Wang (2015). to check in the quadratic effect of leverage on firm value and the quadratic nature of other variables on the relationship of leverage and firm value. We check the rationality of data by using IPS and LLC tests.

We will value the use-value of the firm, proxy by Tobin’s Q ( $V_L$ ) as Dependent variable, while independent variables are Leverage ( $D_{it}$ ) proxied by debt to asset ratio, ZScore (Altman, 1984), Debt Tax shield (Tax) proxied by annual tax, Non-Debt tax shield (Dep) proxied by the depreciation of the year, Free cash flow per share (FCPS), Profitability (EA) proxied by EBIT to net-income ratio, Growth (GR) proxied by the annual change in total assets, liquidity (CR) proxied by current ratio, Tangibility (FA) proxied by fixed assets to total assets ratio, Dividend (DI) proxied by dividend to net-income ratio, and two control variables Size proxied by the log of total assets, Age proxied by the number of years since the company started its operations. Our linear model will be like this

$$V_{L,it} = \alpha_1 + \alpha_2 D_{it} + \alpha_3 Zscore_{it} + Size + Age + \varepsilon$$

$$V_{L,it} = \alpha_1 + \alpha_2 D_{it} + \alpha_3 Tax_{it} + Size + Age + \varepsilon$$

Same we will use different variables along with debt ratio to evaluate their relationship with firm value and as well as their impact on the relationship said above.

Our quadratic model for panel threshold regression study is Hansen’s (1999, 2000);

$$V_{it} = \begin{cases} \mu_i + \theta' h_{it} + \beta_1 D_{it} + \varepsilon_{it} & \text{if } q_{it} \leq Y \\ \mu_i + \theta' h_{it} + \beta_2 D_{it} + \varepsilon_{it} & \text{if } q_{it} > Y \end{cases}$$

$\beta_1$  = is the threshold coefficient when its value is lower than estimated  $Y$

$\beta_2$  = is the threshold coefficient when its value is higher than estimated  $Y$

$Y$  is threshold parameter of any variable  $q$  used as a threshold parameter,  $q$ =(Leverage, Zscore, Profitability, FCPS, Growth, Tangibility) and  $D_{it}$  is the regime dependent variable which is debt to asset ratio in our model

The errors  $\varepsilon_{it}$  are assumed to be independent and identically distributed (i.i.d) with mean zero, and finite variance  $\sigma^2$  ( $\varepsilon_{it}$  i.i.d (0,  $\sigma^2$ ))

“ $I$ ” represents different firms, and “ $t$ ” represents different time periods.  $\mu_i$  is the individual (fixed) effect,

### RESULTS AND DISCUSSION

**Table 2** displays the regression results for a linear model. The results show that there is a positive relation between leverage ( $D_{it}$ ) and firm value ( $V_L$ ), financial quality (Zscore), debt-tax shield (Tax) and non-debt tax shield (DEP), free cash flow (FCPS), and firm profitability (EA) in the presence of leverage. On the other hand, if we see leverage become negative with ZScore, Depreciation, and profitability, while in the presence of Tax and free-cash-flow, leverage is positive.

Table 1: Summary statistics of the variables used in regression.

Variable	Obs	Mean	Std. Dev.	Min	Max
$V_{it}$	3570	1.281	1.523	-8.788	19.641
$D_{it}$	3570	.278	.222	0	1.383
ZScore	3570	1.245	1.092	-.018	21.139
Tax	3570	.203	1.34	-11.055	51.207
Dep	3570	.034	.045	-.028	2.2
EA	3570	.095	.134	-1.961	2.031
FCPS	3570	8.672	70.422	-986.031	1653.51
GR	3570	.125	.323	-.868	9.877
DI	3570	.33	2.58	-35.786	129.839
CR	3570	1.698	3.866	.007	138.527
Tangibility	3570	.443	.216	0	.985

Table 2: Results for hypotheses H1 to H5.

Dependent Variable is Value of Firm

	H-1	H-2	H-3	H-4	H-5
Variables	Coef.	Coef.	Coef.	Coef.	Coef.
VL.it (Lag)	.553*** (19.52)	.823*** (11.69)	.667*** (.015)	.605*** (8.32)	.618*** (21.90)
Dit	-16.152*** (-2.61)	4.818*** (6.05)	-19.207*** (2.609)	29.259** (2.19)	-23.574*** (-3.480)
Z-Score	9.7*** (5.68)				
Tax		15.299* (1.68)			
Dep			97.772*** (37.516)		
FCPS				.244*** (2.64)	
EA					47.474** (2.57)
Size	3.952*** (3.41)	9.461* (4.06)	-.489 (0.321)	8.274** (2.53)	1.083 (1.0)
Age	.078 (0.58)	122*** (0.47)	.179*** (0.04)	.308 (1.045)	.042 (0.25)
Constant	-69.276*** (-3.48)	- 152.907*** (-4.62)	3.861 (5.717)	-146.922*** (-2.86)	-14.613 (-0.80)

Note: Table 4 displays results of system-GMM for hypotheses H1 to H5.

The dependent variable is the value of the firm, which is equal to Tobin's Q. Independent variable is VL.it (Lag) is the lag value of the Dependent variable used in the GMM system method as an explanatory variable. Dit is the leverage of a firm equal to the Debt to Asset ratio of the firm. Z-Score is the Altman financial quality of the firm. Tax is the total tax to EBIT ratio. Dep is Depreciation to total assets ratio. FCPS is Free cash flow to total outstanding shares of the company at the end of the year. EA is the profitability of a firm equal to EBIT to total assets. Size is the log of a firm's total assets. Age is the number of years since the company started its operations.

Table 3: Results for hypotheses H6 to H10.

Dependent Variable is Value of Firm

	H-6	H-7	H-8	H-9	H10
Variables	Coef.	Coef.	Coef.	Coef.	
VL.it (Lag)	.596*** (21.13)	.574*** (6.37)	.86*** (35.04)	.65*** (38.48)	.93*** (53.34)
Dit	-32.022*** (-5.73)	-44.433** (-2.31)	-21.74** (-2.21)	-14.843*** (-3.86)	-25.30*** (-5.45)
GRit	-6.473* (-1.90)				
DI		11.271** (2.16)			
CR			2.306** (2.40)		
FA				-46.957*** (-5.25)	
Dit (Quadratic)					23..26*** (8.66)
Size	1.635 (1.43)	-2.286 (-0.63)	2.842** (2.17)	5.824*** (4.93)	-0.269 (4.48)
Age	.321** (2.43)	.352 (0.81)	.178** (2.00)	.432*** (5.22)	.018 (1.76)
Constant	-25.222 (-1.33)	31.853 (0.53)	-46.63** (-2.18)	-78.273*** (-3.67)	7*** (-4.85)

\*\*\* p<.01, \*\* p<.05, \* p<.1

Note: Table 5 displays results of system-GMM for hypotheses H6 to H10.

The dependent variable is the value of the firm, which is equal to Tobin's Q. Independent variables are VL, it (Lag) is the lag value of Dependent variable used in the GMM system method as an explanatory variable. DIT is the leverage of firm equal to Debt to Asset ratio of the firm. DIT (Quadratic) is the quadratic function of DIT. The purpose is to identify the existence of optimal capital structure. Z-Score is the Altman financial quality of the firm. GRIT is the growth and is equal to the annual change in total assets. DI is the ratio of total dividend to net income. CR is the liquidity of a firm, equal to the current ratio. FA is the tangibility of a firm and is equal to Net fixed assets to total assets. Size is the log of a firm's total assets. Age is the number of years since the company started its operations.

Table 4: Shows threshold statistics and coefficient of variables.

Dependent Variable is Value of Firm						
Threshold variables	(2) Threshold-Level ( $\Upsilon$ )	(3) Lower	(4) Upper	(5) Leverage Coefficient ( $\alpha$ )	F-Stat	
Single Threshold ( $\Upsilon_1$ )					$\alpha_1$	
DIT	0.673*	0.671	0.677	1.11***	2.48	
ZScore	2.02	1.97	2.08	1.085***	2.76	
EA	-0.152**	-0.172	-0.145	0.063**	6.79	
FCPS	104.863	95.775	116.568	-3.022	52.45	
GRIT	0.869*	-	-	1.050***	7.55	
FA	0.576	0.574	0.578	1.0582***	39.83	
Double Threshold ( $\Upsilon_2$ )					$\alpha_2$	
DIT	0.433***	0.430	0.447	-0.974***	17.43	
ZScore	2.99***	2.249	3.028	29.769***	15.87	
EA	0.034**	0.034	0.035	-0.663**	22.33	
FCPS	-11.300***	-12.845	-11.023	34.693***	9.06	
GRIT	0.112	0.0965	0.1760	-4.67**	2.33	
FA	0.687	0.629	0.717	2.719***	104.47	

Note: F-statistics and p-values result from repeating the bootstrap procedures 300 times for each of the three bootstrap tests, \*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10% levels, respectively.

Note:  $\alpha_1$ ,  $\alpha_2$ , and  $\alpha_3$  are the estimated coefficients of the regimes of Debt <  $\Upsilon_1$ , Debt >  $\Upsilon_2$ ,  $\Upsilon_3$ >Debt

Column 1 shows the threshold variable. Column 2 shows the exact threshold value, while column 3 and 4 shows the upper and lower boundary of threshold movement. Column 5 shows the coefficient value of leverage as a result of the threshold level of the specified variable in column 1

Table 3 displays results for the remaining variables, and we can see that growth GR and tangibility FA are having negative while dividend DI and liquidity CR have a positive relationship with firm value in the presence of leverage. While interestingly, leverage has a negative relationship with firm value in the presence of these variables. Finally, we also check the presence of optimal level of leverage in Pakistani industry, we use a quadratic term of leverage, and the result is interestingly positive for leverage, which means that there exists an optimal capital structure.

Table 4 shows results for the Fixed effect -dynamic Panel threshold (Hansen 1999) model. We included results for two thresholds. Only the third threshold is omitted due to space limitations. Column 2 shows the threshold parameter value, which is changing in every row. Column 3 & 4 shows the upper and lower limit for parameter values, while column 5 shows the coefficient value of leverage which is regime dependent variable, as a result of the threshold value of parameter variables. For example, if the debt level is 0.6, the effect of debt on firm value will be 1.1, and if the Z-Score value is 2.02, as a result, at that point effect of leverage on firm value will be 1.085. Then same results for FCPS, growth, and tangibility. The results show that leverage has optimal nature while the other variables are also non-linear in nature.

## CONCLUSION

This study investigated the capital structure of Pakistani firms and its impact on firm value. The study analyses the debt level of firms listed on the Pakistani stock exchange and how other variables impact this relationship. The results show that the mean debt for the overall industry is 0.27, while the highest value is 0.42 for the textile sector only, which is the largest sector in the Pakistani industry. The study further exhibits that firms are not benefitting from leverage in true meaning due to high costs and complicated processes. The findings also show that most of the firms use internal funds for growth and investment, while leverage is avoided due to high costs. Threshold data also shows that other variables like ZScore, Profitability, FCPS, and growth are affecting the relationship between debt ratio and firm value in different ways. Further, the data shows that in the case of negative profitability, debt has a positive and significant coefficient on the value of the firm. The results also show the quadratic nature of leverage; hence we can say that there is an optimal level of capital structure, and above or below this level firm value will be changed depending on other contextual factors like financial quality, level of free cash, growth as well as the size of the firm.

Important findings of the study are H10, which shows the existence of optimal structure, and then threshold analysis verifies it by giving a positive impact of leverage above 0.66, which implies that firms should go for higher loans to get positive benefits.

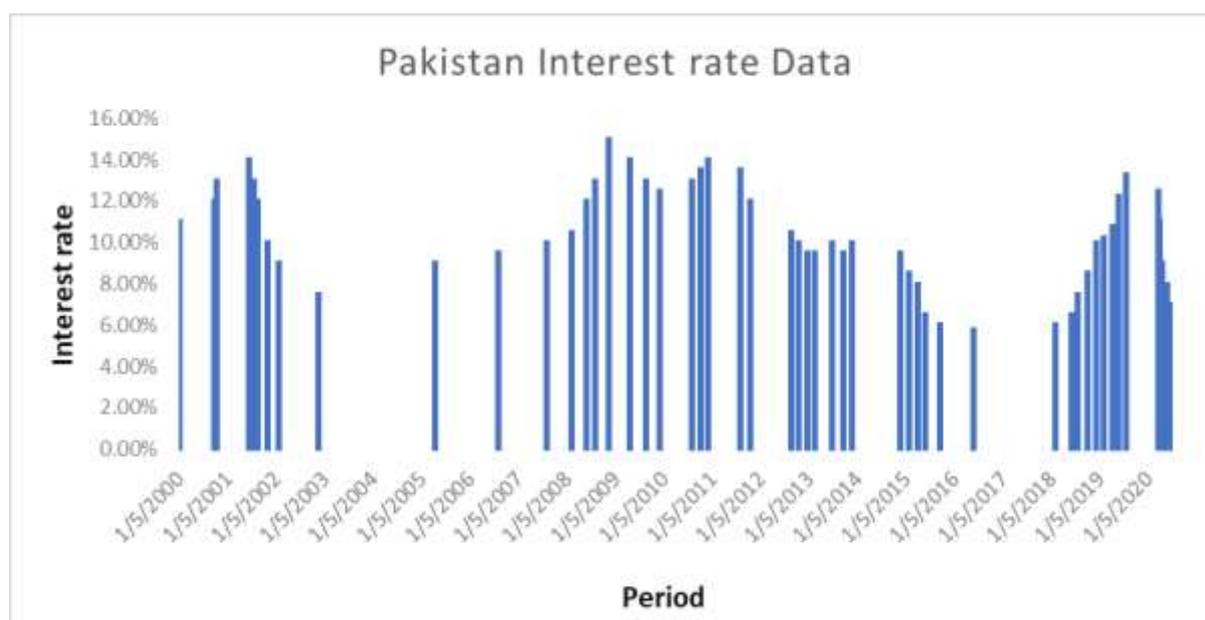
**IMPLICATIONS**

The low level of leverage in Pakistan is due to the high cost, the emergence of Islamic banking, and family control of the business. Private credit from banks to industries matters a lot in economic development. Therefore, government should ease borrowing from banks to strengthen economic development.

We also did a sector-wise analysis, but results are not included due to space limitations. Also, third threshold results, rationality checking (Table 5), and correlation analysis are not included due to space limitations.

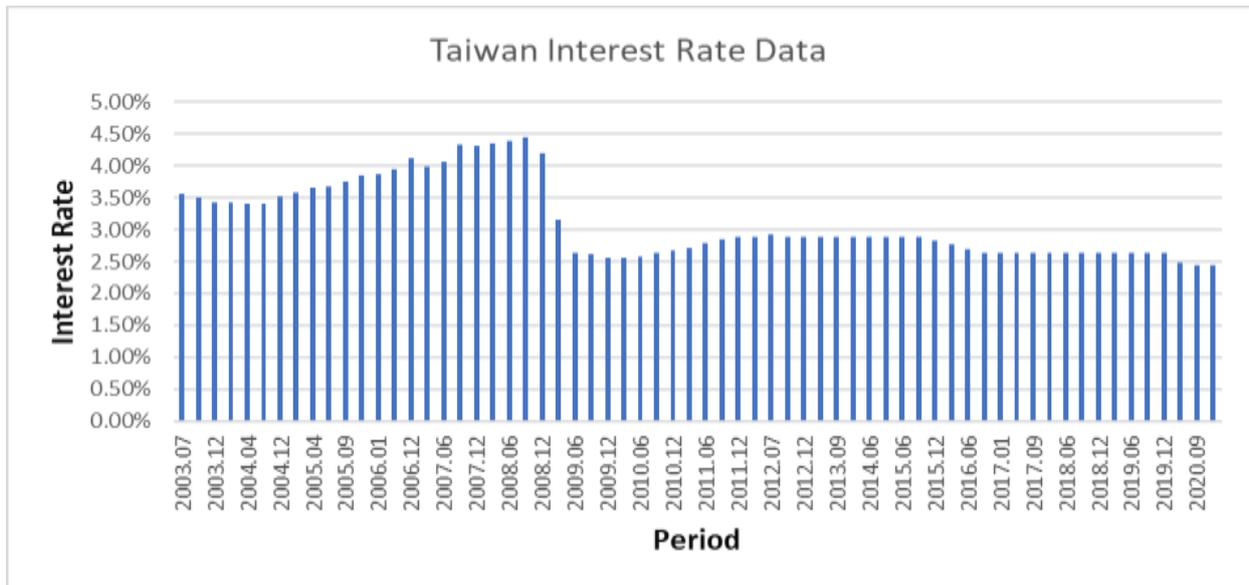
Table 5. Panel unit-root test results.

Variables	LLC	IPS
VL.it	-14.0278***	-1.9767***
Dit	-5.6320***	-1.7984***
ZScore	-13.8323***	-2.0176***
FCPS	-11.1474 ***	-2.5009***
EA	-15.3656***	-2.5318***
GRit	-21.0528***	-4.0579***
FA	-11.9661***	-1.9753***



\*Data Source: State bank of Pakistan.

Figure 2: Pakistan Interest rates statistics (2000 – 2020).



\*Data Source: Central Bank of the Republic of China (Taiwan).

Figure 3: Taiwan Interest rates statistics (2003-2020).

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## Effect of Managerial Capability and Organizational Capability on Digital Innovation Among Organizations in Sri Lanka

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### ABSTRACT

Despite the growing importance of digital innovation to achieve better performance, empirical studies examining different factors that affect digital innovation within organizations are scarce. Further, the findings of existing studies are inconsistent, leading to a knowledge gap within the context. Thus, this research focused on identifying the critical success factors affecting digital innovation from managerial and organizational perspectives. The literature review revealed four factors affecting digital innovation. A new conceptual framework was designed to test the relationships identified, and it was tested using survey data collected from 135 managerial-level employees of organizations that are engaged in digital innovation processes in Sri Lanka. Data were analyzed using the PLS-SEM approach. The findings revealed that top management support and organizational learning had a positive and significant effect on digital innovation. Since there is a dearth of research in the context of digital innovation, the conceptual framework introduced and the findings of the study will encourage organizations to understand and leverage the determinants necessary to foster digital innovation within organizations.

*Keywords:* Sri Lanka, digital innovation, managerial capabilities, organizational capabilities, Dynamic Capabilities Theory

### INTRODUCTION

One of the major challenges faced by contemporary firms in the current dynamic environment is the need to embrace digitalization opportunities permitted by novel digital technologies (Butschan et al., 2019; Ghosh et al., 2017; Loebbecke & Picot, 2015; Richter et al., 2018) and to drive the organization towards a digital transformation through the exploitation of these technologies (Warner & Wäger, 2019). Big data analytics, augmented reality, mobile devices, blockchain, and robotics, etc., have reinvented new business models and value propositions for customers and disrupted the traditional models of business (Sousa-Zomer et al., 2020). Liu et al. (2011) and Vial (2019) have stated that to remain competitive in this environment, traditional firms have also felt the urgency to transform their business models. Based on this premise, digital innovation has become an emerging area of research interest since there is an increasing demand for new digital solutions (Lyytinen et al., 2016).

Thus, for the purpose of this study, digital innovation is identified as “the creation of (and the consequent change in) market offerings, business processes, or models that result from the use of digital technologies” (Nambisan et al., 2017, p.224). A significant amount of literature has provided evidence that there is a positive relationship between innovation and organizational performance (Artz et al., 2010; Kwon-Choi et al., 2013; Clercq et al., 2011; Naranjo-Valencia et al., 2016; Rosenbusch et al., 2011; Valmohammadi, 2017). Further, previous research suggests different types of factors affecting digital innovation such as digital capability (Khin & Ho, 2018), organizational creativity (Sutanto, 2017), entrepreneurial orientation (Mancha & Shankaranarayanan, 2020), digital literacy (Mancha & Shankaranarayanan, 2020), and open communication (Montreuil et al., 2020). It was also observed that the findings of these studies were inconsistent. For instance, management support, although found to have a significant effect on digital innovation in some studies (Montreuil et al., 2020; Scheler, 2013; Shaar, 2015), has been suggested to not have a significant effect on implementing innovation, according to Klein et al. (2001). Further, although communication has been identified as a factor affecting digital innovation, according to Montreuil et al., Grözinger et al. (2020) suggest that communication among team members does not have a significant effect on innovative ideas generation.

As identified above, since it is evident that a number of factors belonging to different dimensions affect digital innovation within organizations and that there are inconsistencies among the findings of different studies, this study aimed to explore the factors which influence digital innovation of an organization, from a managerial and organizational perspective.

### Problem Statement

Although there is an increased research interest for digital innovation, literature on digital innovation has not evolved up to the same level. Majority of research studies on digital innovation look at it from a technical, architectural, or information systems perspective (Lyytinen et al., 2016). The factors affecting digital innovation have not been well established through literature, and the existing findings are inconsistent in nature (Khin & Ho, 2018). Further, Sri Lanka's demographic, economic, social, and cultural background is distinct from the context of countries such as the USA, China, UAE, Taiwan, Iran, Sweden, Spain,

and Indonesia, where studies of this nature were frequently found. This could mean that, in Sri Lankan organizations, there could be a unique set of factors affecting digital innovation. Therefore, due to the dearth of studies related to digital innovation within organizations, the lack of studies identifying managerial and organizational level determinants of digital innovation, inconsistent findings of previous studies in the domain, and the difficulty in generalizing the findings of previous studies done in different countries to the Sri Lankan context, a need arises to determine the antecedents of digital innovation in managerial and organizational domains within the context of Sri Lanka. Based on the above research gaps identified, the researcher developed the following research objectives:

1. To identify managerial capability and organizational capability-related factors affecting digital innovation.
2. To assess the impact of the identified factors on digital innovation.

## **LITERATURE REVIEW**

### **Digital Innovation**

In scientific literature, the concept of digitalization of the innovation process has gained growing attention lately (Brem & Viardot, 2017). As highlighted in various studies, the rapid growth of digital technologies has paved the way for major improvements in many business processes (Galati & Bigliardi, 2019; Levine & Prietula, 2014; Yoo et al., 2012). A major role in the innovation domain has been played by the growth in digital technologies (Holmström & Partanen, 2014; Hylving, 2015). Fichman et al. (2014) have further suggested that digital innovation has the capability of transforming an organization by developing novel business models. Digital innovation has also been known to make certain changes in the competitive environment in which they operate (Vaia et al., 2012). Digital innovation has been regarded as a vital ingredient for organizational success in the current digital age as well (Nambisan et al., 2017). Several studies have examined a cross-industry perspective in identifying the antecedents of digital innovation in different countries (Sousa-Zomer et al., 2020).

### **Theoretical Background**

#### ***Dynamic Capabilities Theory (DCT)***

The dynamic capabilities framework (Teece et al., 1997) is useful in explaining how sustained competitive advantage is attained by organizations. This theory supersedes the perspective of its predecessor - Resource-Based View (RBV) by drawing attention to the modification of resources so that they match with the external environment, ensuring the survival of the firm in turn (Schilke et al., 2018). The key argument in the emergence of DCT is that the RBV has a rather static approach and inadequate foundation in supporting how strategic adaptation occurs in line with the changing business environment (Priem & Butler, 2001; Schilke et al., 2018; Winter, 2003). DCT also suggests that managerial capabilities and organizational capabilities could assist an organization in outstanding its competition and at the same time improve its innovation capability. Beck and Wiersema (2013) and Wang et al. (2013) have identified managerial capabilities and organizational capabilities as a part of dynamic capabilities. This study focused on the definition provided by Teece et al. (2007), where dynamic capabilities have been defined as “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” as the basis in explaining managerial and organizational capabilities.

Based on the above, the researcher used DCT as the theoretical inspiration to support the study's conceptual framework. The following section contains a description of previous research that has looked at various factors that influence digital innovation.

### **Empirical Studies on Factors Affecting Digital Innovation**

Tohidi et al. (2011) and Ghasemzadeh et al. (2019) have identified that organizational learning is positively related to organizational innovation, while Sutanto (2017) has indicated that organizational learning capability and organizational creativity both significantly and positively influence organizational innovation. Wiesböck and Hess (2018) have suggested that digital innovation capability is formulated with digitalization capabilities and digital transformation capabilities. Linke and Zerfass (2011) have identified that internal communication is incidental in fostering an innovative culture. Hu et al. (2012) and Mokhber et al. (2017) have found out that transformational leadership has a positive influence on organizational innovation. Kim et al. (2012) and Hsiao et al. (2014) have highlighted that management leadership and support influence organizational innovation. Basoglu et al. (2013) have stated that quality of communication within the organization has a positive impact on the innovativeness of the organization. Scheler (2013), in her study regarding driving innovation in service organizations, has stated that monitoring the competition arising from the environment, institutionalization of interaction and exchange, top management commitment, systematic approaches, and environmental pressure as conducive for innovation. Zennouche et al. (2014) have indicated that, at the individual level, personality, motivation, and cognition influence innovation, while at group level, structure, climate, leadership, and task influence innovation. Montreuil et al. (2020) and Mokhber et al. (2015) have proposed that some dimensions of transformational leadership positively impact organizational innovation. Shaar et al. (2015) concluded that the top management support directly affects the product innovation and process innovation of a company. Further, Elenkov and Manev (2005) have suggested that there is a significant influence of top management on innovation. Jaiswal and Dhar (2015) have highlighted that; transformational leaders could promote an innovative climate within the organization. Montreuil et al. (2020) have suggested that organizational capability to innovate, leadership, support, communication, culture, and learning impact the organizational capability to innovate.

The researcher performed a frequency analysis based on the above literature where it was evident that the most frequently observed four factors affecting digital innovation were Transformational Leadership (TL), Top Management Support (TMS),

Organizational Culture (OC), and Organizational Learning (OL). These were subsequently classified under managerial and organizational capabilities.

## METHODOLOGY

### Conceptualization

As per the analysis done in the literature review, the four factors that were most frequently observed to be affecting digital innovation within organizations, as stated by most researchers, were selected to develop the conceptual framework of this study. Based on the observations made from the above literature, these factors were broadly categorized under organizational and managerial capabilities. Since literature suggested that managerial capabilities and organizational capabilities can assist an organization in distinguishing itself from the rest of the competition according to DCT (Teece et al., 2007; Teece & Pisano, 1994), this study too, employed DCT to explain the factors recognized under organizational and managerial capabilities. Managerial capabilities refer to all the management actions and behaviors that result in the creation and reconfiguration of the organizational resources (Adner & Helfat, 2003). Organizational capabilities have been identified as those routines and practices which could renew and reorganize the resource base of the organization and enable the organization to cope with change better (Adner & Helfat, 2003). Accordingly, transformational leadership and top management support were classified under managerial capabilities. These were considered managerial competencies because they both pertain to efforts made by the management team to encourage employees to adopt innovative behaviors (García-Morales et al., 2011; Montreuil et al., 2020). Organizational culture and learning were recognized under organizational capabilities since they represent activities that can affect all employees and serve to create a productive change and innovation environment at an organizational level (Adriansyah & Afiff, 2015; Montreuil et al., 2020).

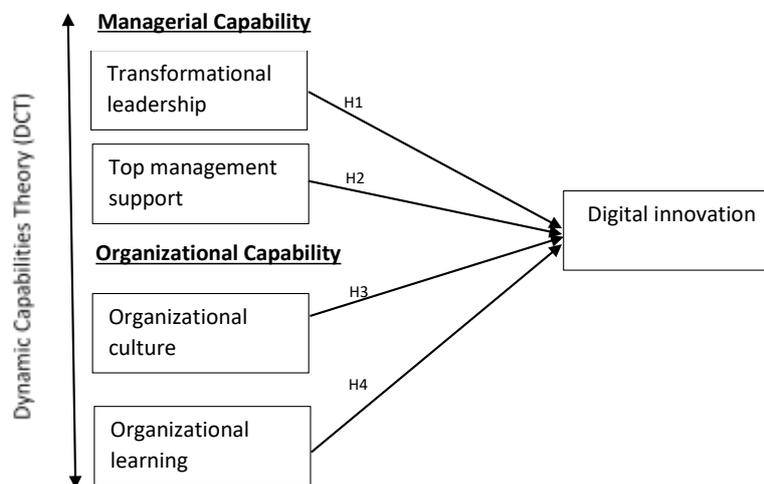


Figure 1: Conceptual framework.

### Development of Hypotheses

Based on the above conceptual framework, the study identified several hypotheses which depicted the relationships existing between the identified variables, and they are explained in the sections that follow.

#### *The Effect of Transformational Leadership on Digital Innovation*

Transformational leadership, as a form of leadership, has proven to be effective in many countries, as a way which both stimulates the followers to achieve unexpected outcomes and develops their own leadership capacities while committing to the group and the organization in the process (Bass, 1985; Bass, 1998; García-Morales et al., 2011). Thus, according to García-Morales et al. (2011), transformational leadership is defined as the style of leadership that heightens the consciousness of collective interest among the organization's members and helps them to achieve their collective goals. Bass further describes the transformational leadership style to be identified under several features, namely, idealized influence, attributive charisma, inspirational motivation, intellectual stimulation, and individualized consideration. There have also been studies that signify that transformational leadership characteristics positively impact innovation (García-Morales et al., 2008; Gumusluoglu & Ilsev, 2009; Jung et al., 2003; Khalili, 2016; Sattayaraksa & Boon-itt, 2017; Uddin et al., 2017). Transformational leadership is understood to be related to organizational innovation through several features such as collaborative vision, active communication, and an environment that fosters innovative teams (Aragon-Correa et al., 2007). Based on the above premise, the following hypothesis was proposed:

H1: There is a positive effect of transformational leadership on digital innovation

#### *The Effect of Top Management Support on Digital Innovation*

Top management support refers to the provision of the support needed for operating processes and also to the role of providing instructions on operating a business (Rodriguez et al., 2008; Rosenbloom, 2000; Swink, 2000). Top management support is said to demonstrate a crucial role in building an organization's innovation-related strategies (Hsu et al., 2018). Tidd et al. (2001) and Tushman and O'Reilly (1997) have shown the vital impact top management has in providing the necessary resource requirements and deploying reward structures to promote innovative initiatives within the organization. Several early studies have supported the notion that in order to foster innovation within organizations, it has to be supported by the top management (Deshpandé et al., 1993; Kohli & Jaworski, 1990; Li & Calantone, 1998). The top management usually makes arrangements for the resource requirement and provides the support needed for achieving innovation success (Rodriguez et al., 2008). When elaborated further, management support is crucial for organizational innovation in a scenario where the employees are given the help and encouragement needed for the new initiatives they are trying to implement (Anderson & West, 1998; Sarros et al., 2008). The relationship between top management support and innovation has received substantial attention in previous literature (Kim et al., 2012; Sharma & Rai, 2003; West et al., 2003). Based on the above premise, the following hypothesis was proposed:

H2: There is a positive effect of top management support on digital innovation.

### ***The Effect of Organizational Culture on Digital Innovation***

Schein (2004) refers to culture as values and beliefs shared by members of an organization that guide the expected behavior. The swift changes taking place in the digital innovation field necessitates an organization to foster a culture that promotes innovation performance in order to remain competitive in the industry (Shahzad et al., 2017). Several studies have provided evidence to the substantial relationship that exists between organizational culture and innovation (Clercq et al., 2011; Lounsbury et al., 2019; Lau and Ngo, 2004; Mavondo and Farrell, 2003; Miron et al., 2004). A study by Hislop (2013) has further established that innovation within organizations is impacted by the values of the organization, its beliefs, working environment, sharing of knowledge, and all the cultural aspects within the organization. Based on the above premise, the following hypothesis was proposed:

H3: There is a positive effect of organizational culture on digital innovation.

### ***The Effect of Organizational Learning on Digital Innovation***

Organizational learning is regarded as a major dynamic capability of organizations, and learning organizations are said to promote the said capability (Aragon-Correa et al., 2007; Senge, 1994). Organizational Learning is regarded as a process that increases the knowledge of individuals and transforms it into organizational knowledge. Further, it is an exemplification of the organizational culture. When considered as an element of culture, organizational learning can understand people's thoughts, actions, and practices (Jablin & Putnam, 2001). Learning has been identified to enable the organization to identify and remedy its mistakes in order to get acclimatized to the environment better (Asgarnezhad Nouri et al., 2016; Nouri and Ghorbani, 2017). Kiziloglu (2015) states that in the absence of a learning process, there will be a repetition of similar practices, hindering opportunities for innovation. The positive relationship between organizational learning and innovation has been highlighted in several previous studies on innovation (Chen and Chang, 2012; Hussein et al., 2014; Lee and Song, 2015; Wang and Ellinger, 2011; Salehi and Naseri, 2017). Several studies have posited that learning has been known to enhance the performance of an organization in terms of innovation (Lloréns Montes et al., 2005; Liao et al., 2008; Tohidi et al., 2011; Chen & Chang, 2012). Noteboom (2010) has further suggested that a learning organization can be regarded as an innovative organization. Also, on the other hand, it has been found that when the innovation achieved by an organization becomes greater, the level of learning and change required also becomes greater (Sanz-Valle et al., 2011). Based on the above premise, the following hypothesis was proposed:

H4: There is a positive effect of organizational learning on digital innovation.

### **Overall Design of the Study**

In terms of the research design, the researcher approached the research question through an explanatory technique where it attempted to investigate the causal relationship between several variables. This research design had been followed by several previous authors in the domain as well (Hsu et al., 2018; Lita et al., 2020; Tohidi et al., 2011). Further, the study followed a quantitative research method and adapted a survey technique to gather data similar to previous authors such as Hsu et al. (2018), Mokhber et al. (2017), Lita et al. (2020), Rajapathirana & Hui (2017) and Tohidi et al. (2011) who have also followed a survey-based research strategy.

### **Questionnaire Development**

When developing the items of the questionnaire, a total of 112 previous articles were referred to. Out of the articles referred, the most suitable and reliable questions were selected, focusing on the key authors recognized in each field as well as articles published in high-ranked journals, as applicable to the variables measured in this study. Some of the items were adapted to suit the digital context of the study.

### **Pilot Study**

The sample size of a pilot study is regarded to be small and could be varied between fifteen (15) to thirty (30) (Saunders et al., 2019). Accordingly, the researcher conducted a pilot study involving 21 respondents, who were several industry practitioners belonging to organizations undergoing a digital transformation process/ or have digital innovation initiatives in place within the organization. The responses obtained from the pilot study were analyzed using Smart PLS version 3. Based on the comments received during the pilot study and the results of the data analyzed from the pilot study, several revisions were made to the questionnaire. The revised questionnaire was subsequently distributed among the target respondents. To avoid issues with common method bias, due care was exercised at the designing stage of the questionnaire to ensure the accuracy and understandability of the questions by carefully wording each questionnaire item and obtaining expert opinion prior to distributing the questionnaires among respondents (Podsakoff et al., 2003).

### **Unit of Analysis and Sampling Technique**

The unit of analysis of the study was a single organization, inspired by the studies of Mokhber et al. (2017) and Lita et al. (2020). Self-administered online survey questionnaires (Google forms) consisting of items of a Likert scale were distributed among the selected organizations via email. Due to the practical difficulties associated with randomly reaching out to cover the entire population where the population is very large and unquantifiable, time constraints, and restrictions of access due to restrictions in travel imposed with the Covid-19 pandemic situation in the country, it was decided to select convenience sampling as the sampling technique of the study. Convenience sampling has also been followed in several previous studies conducted within the domain (García-Morales et al., 2008; Iqbal et al., 2018; Nouri & Ghorbani, 2017).

### **Data Collection**

The questionnaires were sent out based on the contact information obtained from the current and past MBA candidates of the University of Moratuwa, University of Sri Jayewardenepura, University of Colombo, and the Postgraduate Institute of Management in Sri Lanka. Another set of questionnaires was also distributed among the managerial level employees of leading organizations within the Western Province of the country, based on personal contacts. A filtering question was entered at the beginning of the questionnaire to make sure that respondents belonged to organizations that were engaged in digital innovation initiatives. To ensure the reliability of the study, it was necessary that whoever responded on behalf of the selected organization during the data collection process had an overall understanding of the organization's digital innovation processes, organizational learning initiatives, and culture, etc. To guarantee this, the covering letter of the questionnaire requested only those who belonged to managerial level positions of the organization (E.g., Assistant Manager and above up to Director/Proprietor) to respond to the survey. Selection of the managerial level employees as the respondents was also in line with the previous studies of Mokhber et al. (2017), Rajapathirana and Hui (2017), and Shaar et al. (2015), who have selected managerial level respondents for their studies. Further, in the questionnaire, the section on respondents' demographic information included an item that requested to specify the most appropriate category out of the given list that best matched with the respondents' current positions. Through this, respondents belonging to positions lower than Assistant Manager were identified, and hence the researcher was able to omit their responses from the data analysis process.

## **DATA PRESENTATION AND ANALYSIS**

The minimum required sample size recommended as per Daniel Soper sample size calculator, which is used for PLS SEM-based analyses, was 103. Initially, the researcher planned to collect at least 200 responses with the intention of sufficiently covering the minimum required sample as well as to ensure better validity in responses. However, although 906 questionnaires were distributed, only 197 were received. A total of 709 questionnaires were not received by the researcher. Out of the received responses, the researcher had to eliminate 59 questionnaires since 16 respondents had responded that there were no digital innovation initiatives in place within those organizations, and 43 had responded that they belong to positions below Assistant Manager level. Accordingly, only 138 responses out of the 197 received were usable for the purpose of data analysis. Hence, the total response rate when compared with the total 906 questionnaires sent, as defined by Saunders et al. (2019), was 21.74%, and the active response rate out of the total questionnaires sent was 15.23%.

During the preliminary analysis, the four multivariate assumptions of normality, homoscedasticity, linearity, and multicollinearity were tested. During the analysis of the structural equation model, the measurement model and the structural model were separately assessed, as recommended by Hair et al. (2014).

### **Evaluating the Measurement Model**

Measurement model analysis included evaluation of the reliability of the constructs and indicators and the evaluation of the validity of constructs and indicators. To assess the reliability, assessments of internal consistency and indicator reliability were performed. Internal consistency (construct reliability) was assessed using Cronbach's alpha and composite reliability values. To ensure indicator reliability, individual indicator loadings were inspected. To ensure the validity of the measurement model, convergent validity (assessed using AVE values) and discriminant validity measures (assessed using the Fornell-Larcker criterion) were used.

Table 1 indicates the results of the reliability and convergent validity analyses of the measurement model.

Table 1: Results of the reliability and convergent validity analyses.

Variable	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Organizational Culture (OC)	0.903	0.928	0.722
Digital Innovation (DI)	0.919	0.935	0.675
Organizational Learning (OL)	0.937	0.955	0.840
Transformational Leadership (TL)	0.921	0.938	0.716
Top Management Support (TMS)	0.948	0.960	0.827

The composite reliability values of all the constructs were above the prescribed threshold of 0.7. It was observed that the Cronbach's Alpha value for all the constructs was well above the minimum threshold of 0.7 (Hair et al., 2014) and below the maximum threshold of 0.95 (Hair et al., 2019; Nunnally, 1978).

When considering the variables OC, OL, TL, and TMS, it was observed that the indicator loadings of all the items that were used to measure the variable were above the threshold value of 0.7 as prescribed by Hair et al. (2011). However, when considering Digital Innovation (DI), all the item loadings, except for DI3, were above the threshold. DI3 corresponded to a value of 0.668, which was below the threshold of 0.7. This item was deleted based on Hair et al. (2019) in order to improve the AVE value, and the Cronbach's alpha and composite reliability values of the construct were not adversely affected by this deletion.

In terms of inspecting the validity, it was observed that the Average Variance Extracted (AVE) was greater than the threshold value of 0.5 for all the constructs as recommended by Hair et al. (2011), ensuring the convergent validity of the constructs.

Table 2 indicates the results of the discriminant validity analysis done based on the assessment of the Fornell Larcker criterion.

Table 2: Results of the discriminant validity analysis.

	OC	DI	OL	TL	TMS
OC	<b>0.850</b>				
DI	0.585	<b>0.850</b>			
OL	0.724	0.621	<b>0.917</b>		
TL	0.719	0.557	0.671	<b>0.846</b>	
TMS	0.710	0.646	0.673	0.807	<b>0.909</b>

Table 2 shows that the levels of the square root of the AVE for each construct are greater than the correlation involving the constructs. Therefore, the discriminant validity is established for all the constructs as per the Fornell-Larcker criterion.

### Evaluating the Structural Model

The structural model was assessed using the coefficient of determination ( $R^2$ ) as a measure of the model's explanatory power. According to Hair et al. (2011),  $R^2$  values of 0.75, 0.5, and 0.25 for endogenous latent variables in the model represent substantial, moderate, and weak effects, respectively. The dependent variable in the current study is Digital Innovation (DI) for the purpose of assessing the coefficient of determination ( $R^2$ ). In complex models with multiple regression, the adjusted  $R^2$  value is obtained to remove biasness (Hair et al., 2014). The adjusted  $R^2$  value for DI was 0.592. This indicated that the  $R^2$  is satisfactory, and 59.2% of the variation in digital innovation is explained and is moderately influenced by the independent variables.

### Testing of hypotheses

Using the PLS-SEM, the path coefficients and the significance of the relationships were assessed. The significance of the hypotheses of this study was tested using empirical t values at a 5% significance level (threshold value 1.96) (Hair et al., 2014) and p values obtained through the bootstrapping procedure at a 95% confidence level (threshold value 0.05) (Hair et al., 2014). The results are shown in Table 3.

Table 3: Path coefficients and hypotheses testing.

Hypotheses	Path	T statistic	P values	Decision
H1	TL → DI	0.127	0.449	Not Supported
H2	TMS → DI	1.871	<b>0.031</b>	<b>Supported</b>
H3	OC → DI	0.025	0.490	Not Supported
H4	OL → DI	<b>2.617</b>	<b>0.005</b>	<b>Supported</b>

The results of the hypothesis test indicated that H2 and H4 were supported at the 95% confidence level, and H1 and H3 were not supported at the 95% confidence level.

### DISCUSSION AND FINDINGS

The first objective of the study was to identify the factors which influence digital innovation under organizational capability and managerial capability. To fulfill this objective, an extensive literature review was carried out. Through the previous studies, four key factors influencing digital innovation were identified. Based on the literature, the conceptual framework was then developed by using these identified factors and hypothesized relationships to find out whether the identified factors have a positive impact on the digital innovation of an organization.

The second objective was to assess the impact of the identified factors on digital innovation. This objective was achieved by testing the four hypotheses identified above from H1 to H4. The analysis revealed that H1 was not supported ( $p > 0.05$ ), indicating that transformation leadership does not have a significant effect on digital innovation. The findings of this study contradict those of Montreuil et al. (2020) and (Mokhber et al., 2017), who have suggested that there is a significant positive effect of transformational leadership on digital innovation. However, there have also been inconsistent findings on the impact of transformational leadership on innovation. For example, there have been findings which suggested that among the sub-dimensions considered under transformational leadership suggested by Bass and Riggio (2006) – intellectual stimulation, individualized consideration, idealized influence, and inspirational motivation, idealized influence has a non-significant relationship with innovation. (Al Ahmad et al., 2019; Jaussi and Dionne, 2003; Li et al., 2016). Jaussi and Dionne (2003) suggested that even if a person is not a transformational leader, any unconventional behaviors shown by a person may be more incidental for innovative outcomes, and these unconventional behaviors explain more variation in innovative outcomes than transformational leadership. Based on these facts, it can be stated that transformational leadership may not always be a guaranteeing factor for organizational innovation, since people with unconventional behaviors within organizations, could also be highly influential for the innovative outcomes of those organizations, even though they are not labelled as transformational leaders. Further, all the traits of a transformational leader, as defined by Bass and Riggio, may not always have a significant effect on digital innovation.

The analysis indicated that H2 is supported ( $p < 0.05$ ). Hence, it can be concluded that top management support has a significant effect on digital innovation. This finding is consistent with several previous studies, such as Shaar et al. (2015) and Elenkov and Manev (2005), who suggested that there is a significant influence of top management on innovation. This finding is further consistent with those of Hsu et al. (2018), who posited that top management support performs a vital role in designing the innovation-related strategies of an organization, and that of Jaiswal and Dhar (2015), who stated that the top management significantly affects the innovative climate of an organization.

As per the analysis, H3 was not supported ( $p > 0.05$ ). This indicates that there is no significant effect of organizational culture on digital innovation. This finding is consistent with the findings of Naranjo-Valencia et al. (2016), who suggested that neither there is a significant relationship between clan culture and organizational innovation nor between market culture and organizational innovation. They further suggested that although traits such as teamwork that are inherent in clan cultures are influential for innovation, they may be effective only when remaining values pertaining to external orientation are present. Naranjo-Valencia et al. further posited that even though the market cultures which are more oriented towards the external environment are supportive of innovation, they may hinder innovation where there is a mechanistic structure, excessive hierarchies, focus on too many details, and excessive pressure on employees. They concluded that although organizational culture may foster innovation, it can also act as an obstacle against innovation. Chen et al. (2018) also posited that the connection between an organization's culture and its innovative strategy is not significantly related to the speed and the quality of innovation of an organization. According to these facts, it could be implied that organizational culture may not always have a positive influence on innovation and that it may depend on different cultural contexts observed within different organizations in the way they are supported by their organizational structures. The finding of this hypothesis, however, is inconsistent with several previous research that had posited that the organizational culture affected positively and significantly on innovation (Aboramadan et al., 2019; Montreuil et al., 2020; Nguyen et al., 2019; Lita et al., 2020; Sousa-Zomer et al., 2020).

According to the analysis, H4 was supported ( $p < 0.05$ ), indicating that there is a significant, positive association between organizational learning digital innovation. This finding is consistent with the findings of previous studies, which have also posited a significant, positive relationship between organizational learning and innovation (García-Morales et al., 2011; Hsiao et al., 2014; Montreuil et al., 2020; Sutanto, 2017; Tohidi et al., 2011). Learning is also regarded as an important factor for organizational innovation since it permits organizations to realize the mistakes by themselves and their competitors and correct them with the view of adapting to their environment (Nouri et al., 2016). This finding was further consistent with the suggestion that the individual expertise of employees and new knowledge entering the organization is incidental in nurturing innovation (Lin, 2007).

### CONCLUSION

This study attempted to determine the factors which affect digital innovation with reference to managerial and organizational capabilities. To explain the relationship between identified antecedent factors and digital innovation, this study used DCT. Analysis of literature revealed the existence of four factors that affected digital innovation. They were transformational

leadership, top management support, organizational culture, and organizational learning. These factors were then regrouped under managerial and organizational capabilities, based on theoretical justifications. According to the analysis, top management support and organizational learning were identified as the two factors which have a significant positive influence on digital innovation, while transformational leadership and organizational culture do not have a significant influence on digital innovation.

## IMPLICATIONS, LIMITATIONS, AND FUTURE RESEARCH DIRECTIONS

### Implications

As mentioned in several studies within the domain, comprehensive models and literature are deemed to be lacking when it comes to identifying the antecedents for digital innovation (Khin & Ho, 2018; Loon et al., 2020; Vial, 2019). Through a comprehensive literature review, four factors affecting digital innovation were identified, filling the existing knowledge gaps with reference to empirical studies. Secondly, a new framework unique for this study was developed to fill the knowledge gap existing within the subject area of digital innovation.

The findings could provide inference on specific factors which could have an impact on the digital innovation processes within different organizations, as well as within capabilities of which nature (managerial or organizational) these factors should be leveraged. Managers should focus more on enhancing their support towards innovative initiatives and fostering organizational learning efforts in order to improve the digital innovation processes, according to this study. This may mean investing more in technologies and digital infrastructure to develop new products, services, and work processes (OECD, 2020) and allowing new knowledge to enter and flow freely within the organization (García-Morales et al., 2011). Based on the findings, managers need to take necessary steps to build, lead and leverage a digitally innovative organization, and drive it towards better performance outcomes. In order to achieve this, it is imperative that the organization possesses the appropriate structure, culture, and work processes conducive to digital innovation (Hilmi et al., 2010). The findings could also be helpful for government policymakers to promote digital innovation at regional and national levels, especially aiming organizations that are still rooted in traditional modes of operating, and to communicate the importance of fostering a management structure and a learning environment that support digital innovation to achieve better organizational performance.

### Limitations of the Study

It is acknowledged that the current study consisted of several limitations. These limitations could lead the way for additional investigations in future studies in the domain. The researcher had to restrict the study to the Western Province in Sri Lanka and had to rely only on online modes for collecting data due to travel restrictions and practical difficulties in visiting organizations physically due to the COVID-19 pandemic. Even after three to four email reminders, the final usable responses only amounted to 135. Therefore, the generalization of the findings of this study needs to be done carefully, especially for other regions, organizations, and the entirety of Sri Lanka. Due to the restrictions mentioned above, the researcher also had to adapt a convenience sampling method, and generalizing the results of the convenience sampling method to the entire population could be questionable.

### Future Research Directions

The conceptual framework introduced in this study could be extended to compare the differences in the antecedents of digital innovation in different sectors and what factors determine the digital innovativeness of organizations, provided the different economic sectors/industries they belong to. Furthermore, this study has considered four antecedents of digital innovation, as appeared in previous literature. However, there are other variables that have also been considered as factors that affect digital innovation, such as digital orientation (Khin & Ho, 2018), entrepreneurial self-efficacy, digital technology self-efficacy (Mancha & Shankaranarayanan, 2020), and CRM practices (Valmohammadi, 2017). These factors and any additional factors could also be incorporated in future studies. In addition, future studies could be extended to examine the effect of digital innovation on organizational performance.

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## Factors Affecting the Consumers' Purchase Intention and Willingness-to-Pay More for Electric-Vehicle Technology

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### ABSTRACT

This study conducted an in-depth analysis of the factors affecting consumers' intention to purchase and willingness to pay more for an electric vehicle (EV) in the developing-country context, extending the theory of planned behavior with two new variables: environmental concern and willingness to pay (WTP) a premium. Survey data were collected from 358 responses and were analyzed using partial least squares structural equation modeling. Multi-group analysis was conducted, and the moderating role of gender was examined. The findings showed the significant effects of the theory-of-planned-behavior variables and environmental concern on EV technology purchase intention. The present study provides theoretical contributions and policy guidelines concerning high (vs. low)-sensitivity consumer attitudes toward EV technology that marketers and automobile manufacturers can make use of when designing and strategizing their pricing strategies.

*Keywords:* Electric vehicle technology, purchase intention, theory of planned behavior, willingness to pay more, automobile industry.

### INTRODUCTION

The issue of greenhouse gas (GHG) emissions has become one of the most debated issues globally. The emergence of ecological problems has given rise to global warming, energy crises, climate change, ozone layer depletion, air pollution, and depletion of natural resources, all of which have a substantial impact not only on the ecosystem but also on consumer wellbeing (Shah, 2015). Global communities have been recognizing the impacts of these ecological problems on environmentally socially responsible activities, and this has led to the organization of international climate forums such as the Bonn Climatic Conference (2017), the Paris Agreement (2015), and the Copenhagen Conference (2009).

Carbon dioxide (CO<sub>2</sub>) has been reported to be the most highly emitted GHG in the atmosphere. These emissions mainly come from the transport sector (World Health Organization [WHO], 2019). An increase in gross domestic product improves the per capita income in a country, which increases the rate of vehicle ownership (Jain, 2006). This ultimately generates more energy consumption and results in higher CO<sub>2</sub> emissions globally.

Hybrid and electric vehicles (EVs) can be considered technological solutions to the problem of GHG emission as they can reduce GHG emission (Bhutto *et al.*, 2020) by replacing gasoline vehicles (Asamer *et al.*, 2016). EVs, in the context of this study, have electric batteries consisting of hundreds of lithium-ion cells plugged in parallel series and are charged with cables connecting the batteries to the optimal electric current and voltage. According to the International Energy Association (2018), adopting such innovative technology can be an effective strategy to minimize the GHGs emitted into the atmosphere by fossil fuel vehicles, which account for 21% of the total emissions from the transport sector worldwide.

In emerging and developing countries, the transport sector plays a key role in socio-economic development but contributes to severe air pollution with motorization and urbanization. Despite these challenges and the proliferation of EVs and associated technologies, research considering and examining the consumer perspectives on the purchase and use of EVs is scarce. Moreover, much of the research that has been conducted on this topic has considered the Western regions, overlooking the non-Western or emerging/developing countries with high population densities and demands for transport means, including EVs, for the people's regular commute.

To fill the aforementioned research gap, this study was conducted in a non-Western country and investigated people's EV purchase intention. We provided a theoretical framework for our research and empirically tested the hypothesized relationships of certain factors with consumers' EV purchase intention and willingness to pay more for an EV. We also gathered insights from male and female consumers on the factors that most strongly affect their EV purchase intention and willingness to pay more for an EV. Venkatesh and Morris (2000) consider investigating gender differences in this regard important for two reasons. First,

men's and women's decision-making processes are different. Second, as Zhou *et al.* (2014) reported, information can easily be obtained from both men and women, and marketing managers can monitor different gender segments using different marketing strategies.

The following research questions were thus proposed: What factors influence EV purchase intention and willingness to pay more for an EV? Are there gender differences in terms of EV purchase intention and willingness to pay more for an EV? Do the explained variances in the theory constructs differ between males and females?

Pakistan, a non-Western country, was selected for this study for two reasons. First, it is fast becoming more urbanized and is undergoing rapid motorization. In the last decade, the automobile industry showed rapid growth (63% and 69%, respectively) from 2010 to 2018 in terms of production and sales (PAMA, 2018). Second, the WHO (2019) cited the cities of Lahore, Peshawar, and Rawalpindi in Pakistan as the most polluted cities globally, with their high air pollution levels giving rise to airborne disorders and untimely deaths.

EV technology covers a wide range of transport means, including cars, trucks, buses, and motorcycles, but only electric cars were included in this study.

For the remaining sections of this paper, section 2 presents and discusses the theoretical background of the research; section 3, the research model and hypotheses; section 4, the research method that was used; section 5, the study results; and section 6, the discussion and implications of the study findings, the study limitations, and the future research directions. Section 7 concludes the paper.

## THEORETICAL BACKGROUND

### Theory of Planned Behavior

Ajzens' theory of planned behavior was used to measure consumer behavior. According to this theory, the first predictor of purchase intention is attitude. Attitude refers to "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object" (Fishbein & Ajzen, 1975, p. 211). However, attitude also shows consumers' likes and dislikes, which may indicate consumers' intention to purchase green products. Therefore, attitudes can be general or specific (Chen & Chai, 2010). A specific attitude reveals the stronger antecedent of a single behavior in a particular industry or object/product/service, while a general attitude shows a common predisposition involving a significant behavior (Tan, 2011).

The second predictor of purchase intention, according to Ajzens' theory of planned behavior, is the subjective norm. The term refers to "the perceived social pressure to perform or not to perform the behavior" (Ajzen, 1985, 2002). Social norms are influenced by one's peers, family members, friends, or prominent members of the community and exert pressure on people (Fishbein & Ajzen, 1975).

The third predictor of purchase intention, according to Ajzens' theory of planned behavior, is perceived behavioral control, which consists of two constructs: self-efficacy and controllability (Ajzen, 2002). Self-efficacy pertains to a person's ease or difficulty of carrying out a certain intention or behavior that he/she wants to carry out, also known as internal control, according to Armitage and Conner (1999). Another construct of perceived behavioral control is controllability, which pertains to a person's belief that individuals have control over their own actions. The addition of perceived behavioral control extends the theory of reasoned action into the theory of planned behavior, whose predictive power has been significantly increased. Perceived behavioral control belongs to the "rational-choice model," which assumes that "people behave rationally and logically during the process of decision making" (Ajzen, 1991, p. 182). Several management scholars (e.g., Bhutto *et al.*, 2020; Channa *et al.*, 2020; Kumar *et al.*, 2017) have frequently used the theory of planned behavior and have found that perceived behavioral control is its fundamental factor.

### Environmental Concern

Environmental concern shows consumers' emotional responses to environmental issues, including compassion, dislike, and worry (Ramayah *et al.*, 2012), and considerations to ensure environmental quality (Yeung, 2004). For instance, several studies have validated the environmental-concern impacts on the green product choice, including organic foods (Hoffmann & Schlicht, 2013) and renewable energy (Bang *et al.*, 2000). People with environmental concerns are likely to have a positive attitude toward green products (Karatu & Mat, 2014).

In particular, reports show that consumers' interest in EVs has been stimulated by their environmental concern and that consumers with higher environmental concern tend to be less price-sensitive toward EVs (Tanner & Wölfling Kast, 2003), showing a higher willingness to pay more for the environmental benefits of the product (Hansla *et al.*, 2008). For example, consumers have shown a willingness to pay more for organic products (Loureiro & Hine, 2002).

### Gender Differences

Gender differences have been widely considered in several studies in the marketing field (Mostafa, 2007), but few studies have been conducted on the effects of gender differences on EV purchase intention and willingness to pay more for an EV in a developing-country context.

## RESEARCH MODEL AND HYPOTHESES

Figure 1 shows the research model in this study. The theory of planned behavior was used in the study, with a focus on a particular behavior of people: EV purchase. However, all the constructs of this theory individually or collectively lead to a consumer intention, which precedes action. The following general rule was developed: the stronger the intention, the more likely the action corresponding to it will occur. Thus, the theory of planned behavior aims to show how people's acquired information and motivation affect their intention and behavior.

### Impact of Attitude on Electric-Vehicle Purchase Intention

Attitudes consist of all the beliefs that influence an individual's behavioral intentions. They are a result of an internal assessment and association process and have a direct role in the development of positive or negative intentions (Ajzen, 2002). In researches on green consumer psychology, attitudes have always been stressed as important antecedents of behavioral intention and real behavior. Various researchers have validated the effect of attitude toward green products on the intention to purchase green products in developed countries (Qi & Ploeger, 2019; Tan *et al.*, 2019; Jaiswal & Kant, 2018). However, the existing literature clearly does not address the impact of consumer intention on consumer purchase behavior in the developing-country context. Thus, the hypothesis below was proposed.

H1: Attitude toward EVs is positively related to EV purchase intention.

### Impact of Subjective Norms on Electric-Vehicle Purchase Intention

From the social-impact perspective, the individuals in a segment seem to be more closely connected to the other segment members than to non-segment members and to be generally influenced by the opinions of the segment and by the normative pressure exerted by it (Ajzen, 1991, 2002). Thus, the segment's influence is viewed as the influence of subjective norms. Various studies have confirmed that subjective norms in the context of social pressure influence consumers to buy green products more than attitude does (Jayaraman *et al.*, 2015; Lai & Cheng, 2016; Lee, 2009). However, the existing literature does not describe the effects of subjective norms on EV purchase intention. Thus, the hypothesis below was proposed.

H2: Subjective norms are positively related to EV purchase intention.

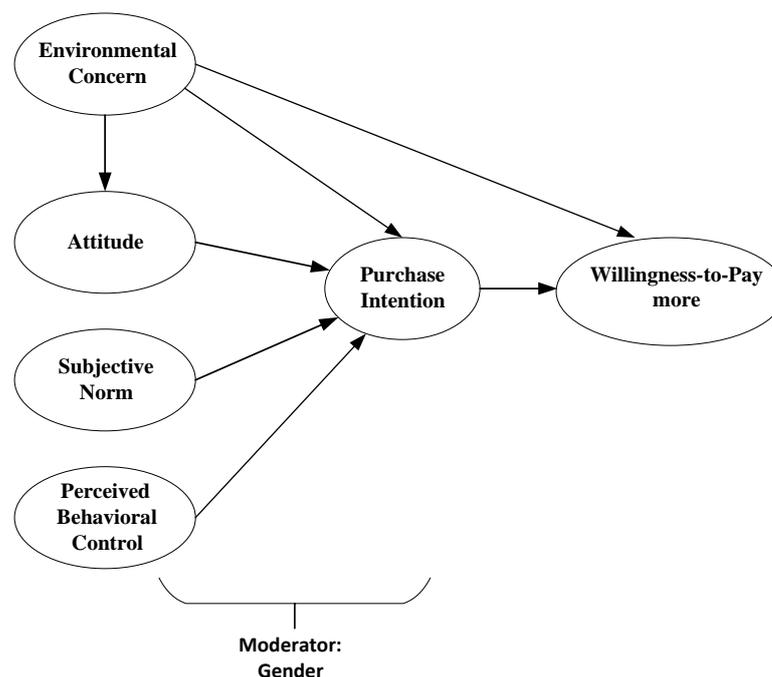


Figure 1: Research Model

### Impact of Perceived Behavioral Control on Electric-Vehicle Purchase Intention

The study reported herein was among the few that had determined the impact of perceived behavioral control on purchase intention. Joergens (2006) argued that many consumers prefer to buy non-green products due to the high prices and unaffordability of eco-friendly products. Thus, the purchasing power control factor appeared to be the major consideration for deciding to purchase healthy food products or not (Mai & Hoffmann, 2012). The government interventions in terms of policy and regulations support consumers' EV purchase behaviors and their willingness to pay more for an EV (Helveston *et al.*, 2015; Oreg & Katz-Gerro, 2006; Sang & Bhet, 2015). They are thus important predictors of green consumption behavior and have been confirmed to have a positive relationship with EV purchase intention (Egbue *et al.*, 2017).

Thus, the market for EVs is still an emerging market, and consumers' self-efficacy and control leading to a willingness to buy at a premium is the most important factor that determines EV purchase intention. The pertinent studies clearly lack an explanation of the direct and indirect connections between perceived behavioral control and EV purchase intention to be able to accept or reject the hypotheses below.

H3: Perceived behavioral control is positively related to EV purchase intention.

### **Impact of Environmental Concern on Attitude toward Electric Vehicles, Electric-Vehicle Purchase Intention, and Willingness to Pay More for an Electric Vehicle**

A significant driver of EV purchase intention is an environmental concern. This is understandable because EVs have less detrimental effects on the environment than petrol or diesel engines do. Several leading carmakers have resolved to stop their production of non-electric cars in the coming decade. Moreover, Sinnappan and Rahman (2011) reported that consumers with stronger environmental concerns are most inclined toward EV purchase. Generally, the literature (e.g., Bang *et al.*, 2000) also indicates that consumers with a high level of environmental concern are less price-sensitive and are more willing to pay a premium for green products (Moser, 2015). Consumers may be concerned about the environment because they are aware that fossil fuel cars have significant negative effects on the environment. Accordingly, Junquera *et al.* (2016) looked into whether consumers could easily distinguish between the ecological factors of EVs and of gasoline cars and are thus willing to pay a premium for an EV. The hypotheses below were thus proposed.

H4: Environmental concern is positively related to attitude toward EVs.

H5: Environmental concern is positively related to EV purchase intention.

H6: Environmental concern is positively related to willingness to pay more for an EV.

### **Moderating Role of Gender**

The role of gender differences seems important to understand because men and women behave differently from each other because of their different structural positions in the labor market and because of their different socialization processes in terms of how they think, behave, and act with regard to the caregiver role (Blocker & Eckberg, 1997).

The theory of gender socialization (Gilligan & Attanucci, 1988) refers to the socialization process where males and females learn different social values and perceive different expectations of them since their early childhood. For example, Gu and Feng (2020) reported the positive effects of heterogeneous groupings (including individuals and latent groups) on mobility tool purchase, particularly on the choice of EVs, which affects households' future technology adoption in relation to energy equipment preferences. However, the multi-country comparison of Belgium, Denmark, and Italy showed significant differences in the consumers' attitudes towards EVs and EV purchase intention (Barbarossa *et al.*, 2015).

In the context of developing countries, the men from South Asian countries are nurtured to take care of their respective families as the sole breadwinners. They thus become competitive and more insensitive than the women who had grown up playing the role of a caregiver and thus had become more cooperative and compassionate. Past studies (e.g., Lee, 2009; Zelezny *et al.*, 2000) have shown that females show greater concern than males regarding environmental issues and thus have a more positive attitude toward products that aim to save nature and the environment.

Conversely, Huang and Ge (2019) performed multi-group analysis (MGA) of the gender demographics in China and found that males have more positive attitudes toward EVs and stronger EV purchase intentions than females. Very few studies have examined gender differences using MGA to assess consumer attitudes toward EVs and EV purchase intention. Hence, we came up with the hypotheses below.

H7: There is a more significantly positive relationship between attitude toward EVs and EV purchase intention among males than among females.

H8: There is a more significantly positive relationship between environmental concern and EV purchase intention among females than among males.

Environmental concern is a multi-dimensional variable demonstrating susceptibility to showing concern for environmental issues and thus to purchasing an environment-friendly product and to have the willingness to pay more for it (consumer price sensitivity) in terms of time and money (Dunlap & Jones, 2002). We thus formulated the hypothesis below.

H9: There is a more significant relationship between environmental concern and willingness to pay more for an EV among females than among males.

## **EMPIRICAL METHODOLOGY**

### **Participants and Sampling Design**

The target study population was estimated to be around 1.26 million automobile users in Pakistan from 2010 to 2018 (PAMA, 2018), who may have car awareness, including of the electric battery technology and EVs. The survey method was utilized, and online survey questionnaires were sent to about 1,000 automobile consumers for data collection, using a link shared through

Google Form (via e-mail), WhatsApp, and Facebook. The back-translated questionnaires were administered to the automobile users in their local languages (e.g., Sindhi and Urdu) so that responses would be received from them.

A hybrid convenience–snowballing sampling technique was employed to collect data from EV users who were aware of battery and plug-in hybrid EVs. A total of 390 online questionnaires were retrieved, 32 of which were removed due to incomplete data. Thus, a final sample of 358 accomplished questionnaires was retained for analysis. Of the final usable sample, 51.1% were obtained from females, and 38.8% of the respondents had a monthly income of above Rs100,000. As regards age, 67.6% of the respondents were within the 25–35 age bracket, and 22.4% were within the middle age bracket (36 and above). As regards the respondents' education level and marital status, 55.6% had a college degree, and 61.5% were married. The respondents' detailed characteristics are shown in Table 1.

### Measurement Instrument

The online survey form was divided into two parts: the respondents' demographic information and the questionnaire proper. A 5-point Likert scale was adopted for the respondents' response options, ranging from 1 (strongly disagree) to 5 (strongly agree) (Lin & Huang, 2012; Wang *et al.*, 2014). The questionnaire items were obtained from previous studies but were modified to make them fit the research context. To confirm that all the questionnaire items could be clearly understood, a pilot study was conducted with a sample of 50 automobile owners who were students and staff of Sukkur IBA University belonging to different countries and regions of Pakistan and who were obtained via a hybrid convenience–snowballing sampling technique. One professor and two Ph.D. students who were well versed in the research were involved in the pilot study.

Table 1: Demographic Statistics

Demographic Variables	Categories	Sample	Percent (%)
Gender	Male	175	48.9
	Female	183	51.1
Age (years)	≤ 25	58	16.2
	26–35	184	51.4
	36–45	107	29.9
	≥ 46	9	2.5
Education	Undergraduates	70	19.5
	Graduates	199	55.6
	Post-graduates	89	24.9
Marital status	Unmarried	138	38.5
	Married	220	61.5
Income (rupees)	30,000–60,000	125	34.9
	61,000–99,999	94	26.3
	≥ 100000	139	38.8

After the pilot study, the questionnaire with a total of 21 items was found fit for measuring all the constructs therein (refer to the Appendix). However, the constructs of the theory of planned behavior were measured by adopting 14 items from Ajzen (1985), and the Cronbach's alpha values for the theory-of-planned-behavior variables were 0.764 for attitude toward EVs, 0.802 for subjective norms, 0.895 for perceived behavioral control, and 0.860 for EV purchase intention. Environmental concern was measured by four items from Ramayah *et al.* (2012) and Kumar *et al.* (2017), and the Cronbach's alpha of environmental concern was 0.734. Finally, a scale of three items for measuring the willingness to pay more for an EV was adopted and modified as per the requirements of the study from Moser (2015), and the Cronbach's alpha for willingness to pay more for an EV was found to be 0.832.

### Analytical Procedures

Previous studies (Byrne & Vijver, 2010; Channa *et al.*, 2020; Henseler *et al.*, 2009) have suggested that structural models can be analyzed by applying either a variance- or covariance-based approach. We employed the partial least squares structural equation modeling (PLS-SEM) technique for the following reasons: (a) as our study (please refer to the research model, Fig. 1) focused on prediction, we regarded PLS-SEM as appropriate for the study; (b) the preference for PLS-SEM over the traditional multivariate analysis approaches has been highly accepted, according to Haenlein and Kaplan (2004); (c) PLS-SEM's strength is that it can estimate the causal relationship between the latent constructs and their indicators as reflected in the measurement model (Henseler *et al.*, 2009), and can simultaneously predict hypothesized relationships as reflected in structural models (Hair *et al.*, 2016); (d) PLS-SEM has less strict multivariate analysis assumptions and is useful for prediction (Urbach & Ahlemann, 2010); and (e) for exogenous constructs, PLS-SEM helps maximize the explained variance (Hair *et al.*, 2016).

## RESULTS AND FINDINGS

To examine the hypothetical model in this study, we used PLS-SEM version 3.2.8 (Ringle *et al.*, 2015). We conducted the two-step SEM process (measurement and structural model assessment) and then proceeded to conduct PLS Predict and MGA.

### Measurement Model Assessment

Following the instructions of Hair *et al.* (2016) for the analysis of the measurement model, the individual item reliability, internal consistency reliability, content validity, convergent validity, and discriminant validity were determined.

#### Individual item reliability

The reliability of the individual items was analyzed by evaluating the factor loadings of all the individual items for each latent variable (Hair *et al.*, 2016; Hulland, 1999). Accordingly, a factor loading below 0.5 is unacceptable. Following the recommendation of Hulland (1999), the items with minimum loadings of 0.5 were retained. The items' loadings are presented in Table 2.

#### Internal consistency reliability

To ensure internal reliability, the composite reliability (CR) value was used. CR estimates are much less biased than Cronbach's alpha coefficient, and the reliability of a scale may be underestimated or overestimated by Cronbach's alpha (Hair *et al.*, 2011). The CR values should be 0.70 or above (Hair *et al.*, 2011). Table 2 presents the CR values for each latent variable, ranging from 0.817 to 0.918. As the CR values met the criteria recommended by Bagozzi and Yi (1988) and Hair *et al.* (2011), the measures were proven to have adequate internal consistency.

#### Convergent validity

Convergent validity means that the test that evaluates certain constructs with average variance extracted (AVE) values actually tests such constructs (Fornell & Larcker, 1981). The AVE values should be 0.50 or above (Chin, 1998). Table 2 shows the AVE scores obtained in this study, ranging from 0.543 to 0.834, indicating that there was adequate convergent validity.

Table 2: Measurement Model

Constructs	Items	Loadings	Alpha	CR	AVE
Attitude	ATT1	0.903	0.764	0.895	0.809
	ATT2	0.896			
Purchase Intention	PI1	0.877	0.860	0.915	0.782
	PI2	0.907			
	PI3	0.869			
Environmental Concern	EC1	0.739	0.734	0.831	0.555
	EC2	0.626			
	EC3	0.762			
	EC4	0.837			
Perceived Behavioral Control	PBC1	0.779	0.895	0.918	0.615
	PBC2	0.764			
	PBC3	0.724			
	PBC4	0.804			
	PBC5	0.757			
	PBC6	0.805			
	PBC7	0.851			
Willingness-To-Pay more	WTP1	0.864	0.832	0.9	0.75
	WTP2	0.928			
	WTP3	0.803			
Subjective Norm	SN1	0.906	0.802	0.91	0.834
	SN2	0.921			

CR = composite reliability; AVE = average variance extracted

#### Discriminant validity

Considering the recent criticism of the Fornell and Larcker (1981) criterion, we analyzed the discriminant validity through the heterotrait-monotrait (HTMT) method. HTMT follows the multi-trait multi-method matrix developed by Henseler *et al.* (2015) to ascertain discriminant validity. According to Kline (2011) and as also recommended by Henseler *et al.* (2015), if the HTMT

value is greater than 0.85, then there is a discriminant validity issue. Table 3 shows that the HTMT values for all the constructs in this study were lower than 0.85. Thus, there was no discriminant validity issue in this study.

### Collinearity statistics

The variance inflation factor values were obtained in this study. As they were all less than 5, the exogenous variables in this study had no multicollinearity problem.

Table 3: Discriminant validity (HTMT Ratio)

Latent Constructs	Attitude	Purchase Intention	Environmental Concern	Perceived Behavioral Control	Willingness-To-Pay more	Subjective Norm
Attitude						
Purchase Intention	0.507					
Environmental Concern	0.274	0.601				
Perceived Behavioral Control	0.458	0.791	0.492			
Willingness-To-Pay more	0.305	0.673	0.515	0.568		
Subjective Norm	0.493	0.567	0.257	0.598	0.358	

### Structural Model

After determining the significant results of the measurement model, we proceeded to analyze the structural model. The standard bootstrapping method was used to test the hypotheses, and the results are presented in Table 4.

Table 4: Assessment of path coefficients

Hypothesis	Relationships	Beta	T – Values	P-value	Hypothesis
					supported
					(Y/N)
H1	Attitude -> Purchase Intention	0.131	2.450	0.014	Yes
H2	Subjective Norm -> Purchase Intention	0.129	3.161	0.002	Yes
H3	Perceived Behavioral Control -> Purchase Intention	0.481	9.590	0.000	Yes
H4	Environmental Concern -> Attitude	0.189	3.860	0.000	Yes
H5	Environmental Concern -> Purchase Intention	0.249	5.958	0.000	Yes
H6	Purchase Intention -> Willingness-To-Pay more	0.364	8.445	0.002	Yes
R <sup>2</sup> (Purchase Intention) = 0.569					
R <sup>2</sup> (Willingness-To-Pay more) = 0.386					

The results of H1 ( $\beta = 0.132$ ;  $t = 2.429$ ;  $p = 0.015$ ), which states that attitude toward EVs is a stronger predictor of EV purchase intention, were found to be statistically significant. Thus, H1 was accepted. The results of H2 ( $\beta = 0.129$ ;  $t = 3.126$ ;  $p = 0.002$ ), which states that consumers' subjective norms are positively related to their EV purchase intention, were also found to be statistically significant. Thus, H2 was also accepted. The results of H3 ( $\beta = 0.480$ ;  $t = 9.427$ ;  $p = 0.000$ ), which states that perceived behavioral control is positively related to EV purchase intention, were also found to be statistically significant. Thus, H3 was also accepted. The results of H4 ( $\beta = 0.188$ ;  $t = 3.795$ ;  $p = 0.000$ ), which states that environmental concern is positively related to attitude toward EVs, were also found to be statistically significant. Thus, H4 was also accepted. The results of H5 ( $\beta = 0.250$ ;  $t = 5.929$ ;  $p = 0.000$ ), which states that environmental concern is positively related to EV purchase intention, were also found to be statistically significant. Thus, H5 was also accepted. Finally, the results of H6 ( $\beta = 0.364$ ;  $t = 5.218$ ;  $p = 0.000$ ), which states that EV purchase intention is positively related to willingness to pay more for an EV, were also found to be statistically significant. Thus, H6 was also accepted.

### R<sup>2</sup> Assessment

R<sup>2</sup> reveals the proportional variance in the predictive dependent variable(s), which can be interpreted through their independent variables (Elliott & Woodward, 2007). Thus, the acceptable value of R<sup>2</sup> is 0.10, as suggested by Falk and Miller (1992), whereas Hair *et al.* (2011) and Henseler *et al.* (2009) suggested that an R<sup>2</sup> value of 0.75 could explain accuracy substantially, 0.50 could explain it moderately, and 0.25 could explain it weakly. The R<sup>2</sup> values obtained for both EV purchase intention (0.569) and willingness to pay more for an EV (0.386) show that the research model had the goodness of fit or good predictive accuracy (Hair *et al.*, 2016). This further suggests that all the predictable variables combined to explain 57% of the variance in EV purchase intention and 39% of the variance in willingness to pay more for an EV.

**Partial Least Squares Predict Assessment**

PLS Predict assessment aims to analyze the predictive relevance in terms of the quality of the structural model used and the ability to create accurate predictions (Shmueli & Kopplus, 2011; Shmueli *et al.*, 2019). Predictive validity expresses the set of constructs' measures that can foresee the dependent variable (Straub *et al.*, 2004). The present study utilized cross-validation with holdout samples to measure the study model's predictive validity. For the PLS Predict algorithm, we followed the method suggested by Shmueli *et al.* (2016), using SmartPLS software version 3.2.8 (Ringle *et al.*, 2015). This procedure helped us find the prediction error summaries' statistics and the *k*-fold cross-validated prediction error. For example, these include the root mean square and the mean absolute error for the purpose of analyzing the PLS path model's predictive relevance for the constructs. The current study applied two new benchmarks based on the guidelines developed by the SmartPLS team to gauge the study model's predictive relevance.

First, we employed the Q<sup>2</sup> blindfolding procedure to analyze the predictive relevance of the study model. A cross-validated redundancy value Q<sup>2</sup> greater than 0 suggests that the model has predictive relevance (Chin, 1998). As Table 5 shows, the Q<sup>2</sup> value obtained for the model was 0.416 for EV purchase intention and 0.271 for willingness to pay more for an EV, which confirmed that the model had predictive relevance. All the obtained root mean square error (RMSE) and mean absolute error (MAE) values suggested that the values that were found were smaller than the RMSE value in the PLS model and the MAE values in the LM model. Similarly, the Q<sup>2</sup> values in the LM model were lesser than the Q<sup>2</sup> values in the PLS model. The results of the PLS Predict assessment thus strongly establish the study model's predictive relevance.

Table 5: Partial least squares predict assessment

Endogenous Latent Variable Prediction Summary									
	Q2								
Purchase Intention	0.416								
Willingness-To-Pay more	0.271								
Constructs Prediction Summary									
	PLS			LM			PLS - LM		
	RMSE	MAE	Q2	RMSE	MAE	Q2	RMSE	MAE	Q2
PI1	0.667	0.489	0.398	0.676	0.487	0.383	-0.009	0.002	0.015
PI2	0.604	0.443	0.392	0.622	0.454	0.354	-0.018	-0.011	0.038
PI3	0.682	0.51	0.472	0.692	0.519	0.457	-0.01	-0.009	0.015
WTP1	0.803	0.584	0.151	0.808	0.586	0.141	-0.005	-0.002	0.01
WTP2	0.773	0.572	0.245	0.796	0.59	0.199	-0.023	-0.018	0.046
WTP3	0.812	0.62	0.291	0.823	0.62	0.272	-0.011	0	0.019

**Multi-Group Structural Equation Modeling Results**

Using multi-group PLS-SEM analysis, we analyzed the gender differences (male vs. female) between the theory-of-planned-behavior and extended variables (i.e., attitude toward EVs, environmental concern) and the EV purchase intention and willingness to pay more for an EV. Table 6 shows the three hypotheses for the MGA SEM results.

For H7 (female  $\beta$  0.004 < male  $\beta$  0.261;  $p$  < 0.006), the positive relationship between attitude toward EVs and EV purchase intention was significantly stronger for the males than for the females. Unexpectedly, H8 (female  $\beta$  0.003 < male  $\beta$  0.142;  $p$  < 0.002) was supported, showing that the positive relationship between environmental concern and EV purchase intention was significantly stronger for females than for males. As for H9 (female  $\beta$  0.350 > male  $\beta$  0.175;  $p$  < 0.028), it was slightly supported, meaning that the positive relationship between environmental concern and willingness to pay more for an EV was significantly stronger for the females than for the males.

Table 6: Multi-Group analysis structural equation modeling results

Paths	Hypothesized Relationships	$\beta$ Path Coefficients		p-Value new (Male vs Female)
		Male	Female	
H7	Attitude -> Purchase Intention	0.261	0.004	0.006
H8	Attitude -> Willingness-To-Pay more	0.142	0.003	0.002
H9	Environmental Concern -> Purchase Intention	0.175	0.350	0.028

**DISCUSSION AND FUTURE DIRECTIONS**

This study examined how the transport sector influences the environment in terms of air quality and pollution (Oberhofer & Dieplinger, 2014) and whether that significantly affects consumer behavior. We tried to understand the antecedents of the theory

of planned behavior and the impact of environmental concern on the consumers' EV purchase intention and willingness to pay more for an EV and their relative significance.

The relevant literature shows some gaps regarding the robustness of the theoretical framework and the results' generalizability, as discussed in the literature section. For instance, many of the previous studies had a theoretical framework that included only behavioral intentions, or that did not include all the variables of the theory of planned behavior. Few studies have extended the theory of planned behavior by adding variables, and many studies involved only student participants. The present study offset some of these inadequacies by offering an extension of the theory of planned behavior with a sample of different respondents in the developing-country context (i.e., Pakistan). This pioneering empirical study was conducted using an extended theory-of-planned-behavior model (Ajzen, 1991), considering the original constructs' effects on EV purchase intention.

### **Theoretical Implications**

This paper offers an alternative theoretical lens for understanding EV purchase intention and how it is influenced by all the theory-of-planned-behavior variables, environmental concern, and willingness to pay more for an EV in a developing-country context.

The results for H1 suggest that consumer attitude toward EVs is the strongest predictor of EV purchase intention. The findings regarding attitude toward EVs and how it affects EV purchase intention are in line with the theory of planned behavior, showing that consumer attitudes are significant predictors of behavioral intention. Furthermore, the results of the direct effect of attitude toward EVs on EV purchase intention are consistent with those of the previous studies in other contexts on consumer pro-environmental behavior, such as that by Ramayah *et al.* (2012), who stated that consumer attitude is an important predictor of the intention to purchase environment-friendly products. H2 was also supported by the study results, meaning that subjective norms, perceived as having a social influence on people's acts, were also found to have a significant positive effect on EV purchase intention.

In the context of the Pakistani consumers, H3 was supported by the study results, meaning that perceived behavioral control was found to have a significant positive effect on EV purchase intention. Perceived behavioral control concerns people's belief that they have the resources and opportunities needed to be able to carry out a particular action. It can be further divided into two different aspects: the degree to which one believes he or she possesses the "control factors" needed to carry out a certain behavior and the amount of confidence one has in performing a specific behavior (Kim & Han, 2010). This study showed that the more resources and confidence a consumer has in purchasing environment-friendly products, the higher his or her EV purchase intention will be.

The results for H4 and H5 clearly show that consumers' environmental concern has a significant positive effect on their attitude toward EVs and EV purchase intention. This study thus revealed that consumers who care for the environment are likely to have a positive attitude toward EVs and to be willing to pay more for an EV.

In the opposite direction, H6 was supported by the study results. That is, environmental concern was shown to be significantly positively related to willingness to pay more for an EV, meaning that consumers are more willing to pay a premium for an EV if they are concerned about environmental sustainability and thus want to purchase environment-friendly products.

As for the effect of gender on EV purchase intention in the developing-country context, H7 and H8 were supported by the study results, meaning that attitude toward EVs more strongly affects EV purchase intention in males than in females and that environmental concern more strongly affects EV purchase intention in females than in males. The results for H9 add to the existing knowledge that environmental concern has a stronger relationship with willingness to pay more for an EV in females than in males.

This study thus extended the role of environmental concern in EV purchase intention besides assessing the link between the theory-of-planned-behavior variables and EV purchase intention and provided consumers' insights on the relationship between willingness to pay more for an EV and EV purchase intention in Pakistan.

### **Managerial Implications**

First, EV producers are concerned with the price that can influence EV purchase intention. The results of this study suggest that price is a major consideration in buying EVs; that is, consumers are willing to pay more for green products (Bhutto & Hussain, 2019). However, this study enables EV producers to adjust their pricing strategy by focusing on the marketing aspects that promote sustainability. When setting pricing strategies for EVs, EV producers should make sure that such vehicles are better than fossil fuel vehicles in terms of product design, quality, and functionality. The performance will make consumers willing to pay more for an EV.

Second, the findings of this study provide automobile manufacturers with consumers' insights regarding the sustainable consumption patterns of green automobiles. This will help automakers devise and implement a proactive strategy in the competitive market that promotes consumer-conscious subjective norms and the pursuit of environmental sustainability through green-product development (Bhutto & Hussain, 2019).

Third, the results of this study contribute to the achievement of the United Nations 2030 Sustainable Development Goals (SDGs), especially climatic, industrial change, wellbeing and good health, innovative infrastructure, and affordable and clean energy. The manufacture of green automobile products may lead to a sophisticated manufacturing environment that will reduce GHG emissions and will thus have a less negative impact on ecological landscapes. The minimal CO<sub>2</sub> in the atmosphere will lead to healthier populations. Therefore, the development and adoption of green technology contribute to the attainment of a number of SDGs.

Fourth, this study offers scientific results on consumer EV acceptance to EV manufacturers. EVs help improve transportation sustainability, protect the environment, and reduce petroleum dependence.

Finally, the Pakistani government encourages national and international automobile manufacturers to make major investments in electric automobile technology. The production of EVs will open up employment opportunities for domestic and international workers, especially those with automobile production experience.

### Limitations and Directions for Future Research

The present study had various limitations, which could motivate other researchers to further expand their relevant studies. Among the major limitations were that the present study focused only on EV purchase intention and had a small sample size. Further studies on the relationships of new constructs with EV purchase intention with a large sample size may shed more light on the important factors affecting consumer EV purchase intention. This study also focused on automobile consumers; future studies can consider the consumers of other products that contribute to environmental degradation and can investigate the roles played by attitudes, subjective norms, perceived behavioral control, environmental concern, and willingness to pay more for the product in shaping consumers' intention to purchase such products.

This study's sample consisted of various cities in Pakistan, both rural and urban centers. It would be interesting to determine if there is a difference between rural and urban consumers in terms of how the theory-of-planned-behavior variables affect EV purchase intention. An extended version of this study can be undertaken across Pakistan not only to verify this study's results but also to explore the variations across population groups (e.g., different age groups).

Lastly, the impacts of government incentives and reliability (in terms of EV range, facilities, and charging time) should be analyzed, with the aim of determining whether the effects of reliability (in terms of EV range, facilities, and charging time) on attitude toward EVs would be similar or different. This would further reveal the consumers' acceptance of EVs in terms of reliability in the developing-country context.

### CONCLUDING REMARKS

The world is currently facing environmental issues such as air pollution from the transport sector, especially in developing countries like Pakistan. The solutions direly needed for EV technology adoption were thus examined in this study, and policy recommendations were made accordingly. We argue that adopting EVs will solve the problem of air pollution caused by the transport sector and will promote a clean environment, a more robust economy, and power self-sufficiency. Having reviewed the past relevant studies, we gathered that this study was among the few that had attempted to better understand EV purchase intention or EV technology acceptance by investigating its relationship with extended theory-of-planned-behavior variables, environmental concern, and consumers' willingness to pay more for an EV. Among the study's interesting results is that attitude toward EVs has the most significant influence on EV purchase intention and that environmental concern more strongly influences EV purchase intention and willingness to pay more for an EV in females than in males. How the variable of environmental concern affects consumers' willingness to pay more for an EV in the developing-country context is a new addition to the body of literature on EV purchase intention.

To conclude, as EVs emit a low level of carbon compounds, we may conjecture that the consumer reaction to their adoption in developing countries may allow such countries to leapfrog into environment-friendly and sustainable societies (Sharma et al., 2021). The wide use of EVs can abate health hazards and climate change due to their low GHG emissions, paving the way for a safe environment and healthy humans.

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#### APPENDIX: Scale items

##### Attitude: Ajzen (1991)

1. It is environment-friendly to buy EV.
2. It is fuel-efficient to purchase EV.

##### Subjective Norm: Ajzen (1991)

3. Most people who are important to me think I should use EV.
4. Because I care about the people whom I value influence me to use EV.

##### Perceived Behavioral Control: Ajzen (1991)

5. I can buy an EV if I want.
6. It would be easier for me to buy an EV.
7. I am confident to buy EV if it were entirely up to me.
8. I am confident that I will be able to buy an EV.
9. It is mostly up to me to buy or not to buy an EV.
10. I have personal control to feel over buying EV.
11. I have full control over buying EVs.

##### Purchase Intention: Ajzen (1991)

12. I intend to purchase an EV in the future.
13. I will try to consider buying an EV.
14. I plan to switch my FFV with EV.

##### Willingness-to-Pay more: Moser (2015)

15. I accept to pay 10% more for EV.
16. I am willing to pay 10% more for EV.
17. I show my willingness to spend an extra amount of Rs.300,000 for EV.

##### Environmental Concern: Ramayah et al. (2012) and Kumar et al. (2017)

18. I think environmental problems are becoming more and more serious in recent years.
19. Pakistan's environment is my major concern.
20. I am emotionally involved in environmental protection issues in Pakistan.
21. I often think about how the environmental quality in Pakistan can be improved.

## Factors Influencing Continuance Intention to Use Online Learning Management System Platform

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### ABSTRACT

Information technology (IT) developments and the COVID-19 pandemic have impacted learning processes, and all educational and organizational systems have adopted e-learning methods. A learning management system (LMS) is one of the most popular systems to support the e-learning process. This ubiquity, recent mass adoption, along with labor population trends in self-development, motivates us to investigate the factors involved in the continuance intention of LMS. Quantitative research was performed on a sample of 239 workers with LMS experience through an online questionnaire developed based on literature. We have found that the continuance intention was influenced by satisfaction and Task-Technology Fit (TTF). Furthermore, satisfaction was also influenced by performance expectancy, effort expectancy, and hedonic motivation. TTF was found to be influenced by task characteristics and technology characteristics. Finally, we have also found that performance expectancy is influenced by confirmation.

*Keywords:* Learning management system (LMS), continuance intention, online learning platform

### INTRODUCTION

The development of information technology has to lead to the mass implementation of e-Learning in organizations. E-Learning has been defined as learning or training through information technology, typically through the internet (Bakar et al., 2013). As a system that could respond to the needs of a diverse set of users (Islam & Azad, 2015), Learning Management Systems (LMS) has become one of the most adopted forms of e-learning (Cheng & Yuen, 2018). A report by the World Economic Forum (2020) has shown that nearly 40 percent of the labor force has received skill development courses along with the sentiment from employers in moving from traditional courses to e-learning. HolonIQ (2020) has predicted that the e-learning market would raise an additional 10 trillion dollars within 2030. Furthermore, the COVID-19 pandemic has led to the global shutdown of traditional face-to-face education and has led to the mass adoption of e-learning (Ch *et al.*, 2020; World Economic Forum, 2020). The pandemic, coupled with already rising employer demand for digital education (Mouakket & Bettayeb, 2015), thus presented a large market opportunity in 2020, which was fulfilled by a dramatic increase of commercial digital education platforms (Teräs *et al.*, 2020).

Although important (Panigrahi *et al.*, 2018), the adoption and implementation of electronic education is only the first portion of assessing the success of educational technologies. The continual use of such technologies is vital for long-term success (Cheng, 2020b). As such, the investigation of the factors involved in the continuation intention of digital products such as LMS presents itself as a research question. An investigation could yield results for both assessing the success of current and future e-learning products and promoting lifelong learning for the user (Joo *et al.*, 2018). Previous research on continuation intention has been rather disparate, and different papers have utilized different theories and factors in the analysis. The purpose of this research is to synthesize the themes of previous literature in an attempt to provide a comprehensive analysis of the factors of continuation intention in the use of LMS. This research uses a conceptual framework synthesized from the models popularized in literature: The Expectation-Confirmation Model (ECM), Extending Unified Theory of Acceptance and Use of Technology (UTAT2), and the Task-Technology Fit (TTF). We have attempted to identify the most significant variables from previous models and synthesized them into our Conceptual Framework. We can summarize our research aims into five main objectives:

- 1) To study the relationship between the Task Characteristics and Technology Characteristics with the Task-Technology Fit;
- 2) To study the relationship between Confirmation and Performance Expectancy;
- 3) To study the relationship between Satisfaction with Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, and Task-Technology Fit;
- 4) To study the relationship between Continuance Intention with Task-Technology Fit and Satisfaction;
- 5) To improve on the existing models of the factors influencing Continuance Intention in Learning Management Systems.

## LITERATURE REVIEW

Previous research on continuance intention has been based on three quite disparate schools of thought. A major theme in this research paper is to synthesize the ideas of these three major theories in an attempt to create a more comprehensive model for the study of LMS.

The Expectation-Confirmation Theory posited by Oliver (1980) has claimed that a repurchase intention is based on satisfaction delivered from confirming a consumer expectation. The expectation is formed through the product's perceived performance. Meeting or failing this expectation is the crucial factor in deciding if the consumer would possess repurchase intention. Bhattacharjee (2001) has expanded on the ideas presented and has applied this theory on the IS Continuance Intention. In their model, Bhattacharjee framed perceived performance as perceived usefulness (Davis, 1989) and posited that the IS Continuance Intention would be formed from satisfying and confirming the particular perceived usefulness of a technology. Previous research (Cheng, 2020b; Wang *et al.*, 2019; Joo *et al.*, 2016) has identified a causal relationship between confirmation and satisfaction. Consistent satisfaction has been shown to have a positive relationship with continuance intention (Islam & Azad, 2015; Joo *et al.*, 2016).

Parallel research (Venkatesh *et al.*, 2003) has been performed with themes from cognitive theory and has given rise to another model for the use of technology, the Unified Theory of Acceptance and Use of Technology (UTAUT). This model defines use behavior as a function of behavioral intention and places focus on analyzing the factors behind the behavioral intention. Venkatesh *et al.* (2012) later extended this theory (UTAUT2) and identified five main factors of behavioral intention: performance expectancy, effort expectancy, social influence, facilitating conditions, and hedonic motivations. These factors positively influence the user behavior of technology. Use behavior has been linked to continuance intention through satisfaction (Joo *et al.*, 2016; Mouakket & Bettayeb, 2015; Cheng, 2020b).

Goodhue and Thompson (1995) have provided another conceptual model of the utilization of technology. In their Task Technology Fit model (TTF), importance is placed on the relationship between the daily tasks performed by the worker and how the technology directly impacts the performance of such tasks. This fit between technology and task is measured by assessing the characteristics of the task and the characteristics of the technology. Further research (Wang *et al.*, 2016; Ouyang *et al.*, 2017; Bere, 2019) has shown that task-technology fit is positively correlated to satisfaction which in turn leads to continuance intention.

Organizational education has shifted towards e-learning, which typically involves an online connection between educator and student (Aldiab *et al.*, 2019). LMS is a web-based software that could be used to facilitate online teacher-student relations. LMS allows institutions to create and plan courses or certifications and provide students with learning tools, share knowledge, and receive examinations. A lot of LMS are open source, which allows institutions to modify and adapt the software according to their specification. Some LMS are also bundled as commercial options. A comprehensive review of LMS (Kasim & Khalid, 2016) has revealed that institutions have been providing initiatives for all educational institutions to adopt a form of e-learning as a way to improve on the quality education framework. The LMS has thus seen massive adoption in recent times with some of the most popular options, including massive open online courses (MOOCs) such as Udacity, Coursera, and Edx. A learning management system allows institutions to deliver educational content regardless of temporal or physical considerations, and any lesson can be given at any time and any place to anyone with internet access (Joo *et al.*, 2016). Furthermore, the COVID-19 pandemic has put a stop to all traditional forms of face-to-face learning, and many educational and industrial institutions have adopted LMS for employee development. Bhatt & Silva (2020) has shown that LMS holds a very natural integration with more modern systems of online communication that have experienced dramatic growth during the times of the pandemic, such as Zoom, Google Meet, Google Hanging, and Skype. As of the time of writing, the pandemic is still ongoing, and the future of online education remains unclear. Thus, it is natural to ponder upon what sort of factors would allow for an LMS to see continual use post-pandemic.

The purpose of this research would be to synthesize a model based on the previous three theories in order to understand the factors that influence the continuous intention of LMS in Thailand. We would study users of popular LMS (Udacity, Coursera, Edx, Moodle, Blackboard) along with users of simpler forms of online education (Zoom, Google Meet, Google Hangout, Skype). We would also be surveying users of the ThaiMOOC, a massive open online course mandated by the Thailand Cyber University aimed at improving the Thai labor force and more academic users of popular open e-learning services (Khan Academy, Udemey, Canvas, and FutureLearn).

## CONCEPTUAL FRAMEWORK

As stated in the Literature Review, this research is an attempt to synthesize the three extant models of continuance intention in order to provide a comprehensive analysis of the continuance intention of LMS in Thailand. The foundation of our model is the ECM of Bhattacharjee (2001). Previous research (Ifinedo, 2017; Ouyang *et al.*, 2017; Wang *et al.*, 2019; Cheng, 2020a; Zhang *et al.* (2019); Cheng and Yuen, 2018; Chen *et al.*, 2018; Alraimi *et al.*, 2015; Guo *et al.*, 2016) has shown positive relationships between the factors involved in the behavioral intention of the UTAUT2 with the satisfaction of the ECM. However, since most LMS is provided free of charge (Lai *et al.* 2016; Bhatt & Shiva, 2020), we have elected to remove price value as a factor from the behavioral factors under consideration. Furthermore, confirmation has been shown to have a relationship with the performance expectancy of technology (Ifinedo, 2017; Ouyang *et al.*, 2017; Wang *et al.*, 2019). Past research has also shown

links between the TTF with satisfaction and continuance intention. Gan et al. (2017) has also noted that TTF receives a positive by both task and technology characteristics. Figure 1 illustrates our conceptual model.

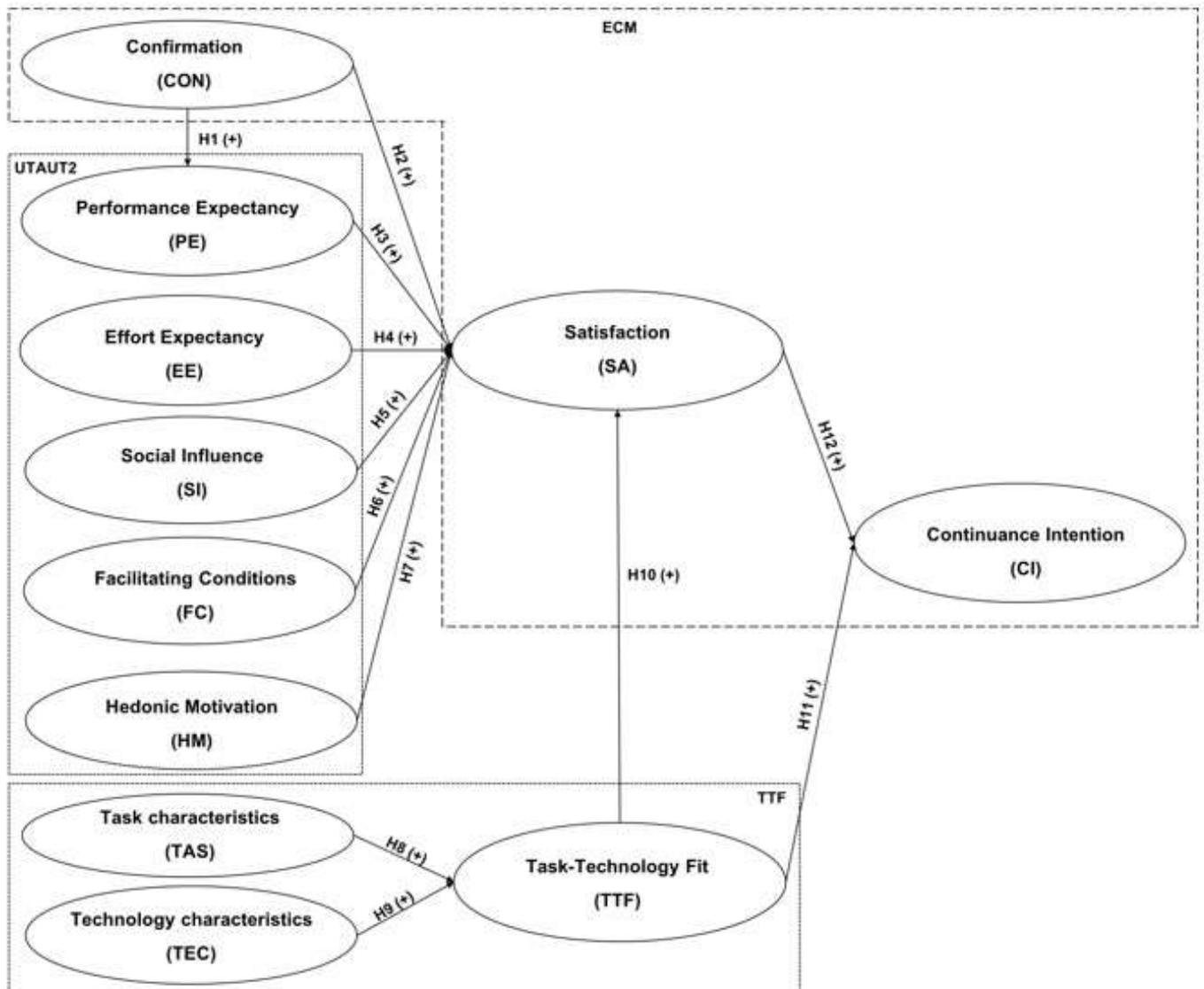


Figure 1: Conceptual Framework.

## METHODOLOGY

### Selection of Respondents

Purpose sampling was applied in order to target the primary research group of members of the workforce with experience with LMS. We have chosen only the members who have completed at least one course and are aged 15 or over with either a salary or at least one hour of work per week. We have sent a total of 303 questionnaires and received a total of 239 valid respondents who fulfill the selection criterion.

### Research Instrument

The research gathered data through the distribution of an online questionnaire. The questionnaire was divided into four sections: screening questionnaires, an explanation of the LMS used, a survey based on the research variables, and personal respondent questions. The answer format of the third part was a 5-point Likert scale (5 – Strongly Agree, 1 – Strongly Disagree). The questionnaire was pretested to analyze reliability with Cronbach's Alpha to ensure reliability.

## DATA ANALYSIS

The questions were analyzed using exploratory factor analysis (EFA) for internal reliability through Varimax rotation. We have found our results to be within acceptable ranges based on the literature review. We present the factor loading values in the table below.

Table 1: Exploratory factor analysis.

Construct	Item Description	Factor Loading
Confirmation	CON2	0.859
	CON3	0.835
	CON1	0.799
Satisfaction	SA3	0.798
	SA4	0.777
	SA2	0.771
	SA1	0.725
Continuance Intention	CI2	0.811
	CI3	0.804
	CI1	0.784
	CI4	0.692
Performance Expectancy	PE1	0.741
	PE2	0.734
	PE3	0.675
	PE4	0.667
Effort Expectancy	EE2	0.716
	EE1	0.703
	EE3	0.695
Social Influence	SI2	0.862
	SI3	0.756
	SI1	0.738
Facilitating Conditions	FC2	0.862
	FC3	0.756
	FC1	0.738
Hedonic Motivation	HM2	0.838
	HM1	0.822
	HM3	0.809
Task Characteristics	TAS2	0.863
	TAS3	0.825
	TAS5	0.659
Technology characteristics	TEC4	0.865

	TEC1	0.716
	TEC5	0.709
Task-Technology Fit	TTF2	0.869
	TTF3	0.836
	TTF1	0.809
	TTF4	0.806

The questionnaire possessed relatively high Cronbach Alpha values, and all factors had Cronbach's alpha exceeding 0.7. This suggests that the measurement items were reliable. We present Cronbach's alpha values in Table 2.

Table 2: Cronbach's Alpha test results.

Construct	Cronbach's Alpha	Number of Questions
Confirmation	0.897	3
Performance Expectancy	0.838	4
Effort Expectancy	0.789	3
Social Influence	0.849	3
Facilitating Conditions	0.813	3
Hedonic Motivation	0.940	3
Task Characteristics	0.7.8	3
Technology Characteristics	0.747	3
Task-Technology Fit	0.887	4
Satisfaction	0.924	4
Continuance Intention	0.918	4

### Hypothesis Testing

We then performed a regression analysis on the hypotheses defined by the conceptual framework. We illustrate our findings in the following table. We observe in our regression analysis that all our values for the Standardized Coefficient  $\beta$  was positive, which suggests that our model was quite accurate in predicting a positive relationship between the variables of the three models. However, some hypotheses were not supported by the regression analysis at the desired significance level.

Table 3: Hypothesis testing.

Hypothesis	Conclusion	Standardized Coefficient $\beta$
H1 (Confirmation $\rightarrow$ Performance Expectancy)	Supported	0.677**
H2 (Confirmation $\rightarrow$ Satisfaction)	Not Supported	0.047
H3 (Performance Expectancy $\rightarrow$ Satisfaction)	Supported	0.189**
H4 (Effort Expectancy $\rightarrow$ Satisfaction)	Supported	0.147**
H5 (Social Influence $\rightarrow$ Satisfaction)	Not Supported	0.052

H6 (Facilitating Conditions → Satisfaction)	Not Supported	0.061
H7 (Hedonic Motivation → Satisfaction)	Supported	0.414**
H8 (Task Characteristics → Task-Technology Fit)	Supported	0.117*
H9 (Technology Characteristics → Task-Technology Fit)	Supported	0.525*
H10 (Task-Technology Fit → Satisfaction)	Supported	0.140*
H11 (Task-Technology Fit → Continuance Intention)	Supported	0.289**
H12 (Satisfaction → Continuance Intention)	Supported	0.581**

\*  $p < .05$  \*\* $p < 0.01$

We have found largely positive correlations during our hypothesis testing. It should be noted that the positive relationship between Confirmation and Expectancy was considerably strong ( $p < 0.01$ ). Furthermore, we have found that the factor that had the largest impact on Satisfaction was Hedonic Motivation. Both Task Characteristics ( $\beta = 0.117$ ,  $p = 0.037$ ) and Technology Characteristics ( $\beta = 0.525$ ,  $p = 0.000$ ) had significant positive relationships with the Task-Technology Fit. Satisfaction ( $\beta = 0.581$ ,  $p = 0.000$ ) was also found to be the most important factor in Continuance Intention.

### DISCUSSION

Our results suggest that a complete analysis of the continuance intention of LMS is supported by our synthesized model. We hope that future research on continuance intention will find utility in our proposed model.

However, some results did not perform as expected. Hypothesis 1 (Confirmation → Satisfaction), 5 (Social Influence → Satisfaction), and 6 (Facilitating Conditions → Satisfaction) were not supported. Similar insignificant relationships between confirmation and satisfaction when trying to use Bhattacharjee's model (2001) on technology have been found (Eren, 2021). We believe that the level of knowledge users have of the product might not be coincident with the actual features of the product. That is to say, users

might not be expecting (and thus not confirming) what could the product could do hence remaining unsatisfied when using the product. Research yielding similar results as Hypothesis 5 and 6 (Teo & Wong, 2013; Roca *et al.*, 2006; Ooi *et al.*, 2018) has been found.

### CONCLUSION

The purpose of this research was to create a synthesized model of the variables under study in the continuance intention of learning management systems. We have synthesized a model-based the Expectation-Confirmation Model (ECM), Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), and the Task-Technology Fit (TTF). This research has shown a significant positive relationship between the factors of these models. We can support Task and Technology Characteristics as large factors of the Task-Technology Fit. We have found that Confirmation had a significant effect on Performance Expectancy. Performance Expectancy, Effort Expectancy, Task-Technology Fit, and Hedonic Motivation were also heavily correlated with Satisfaction, with Hedonic Motivation being the factor with the most impact. Lastly, Satisfaction and Task-Technology Fit can be used as important determinants of Continuance Intention.

We hope that this research could inspire future work using the model presented. The synthesized model given in the conceptual framework was an attempt to create the most comprehensive view of the variables proposed by other researchers, and we hope that the model would be adopted or further improved by future generations.

We have practical suggestions from our result on Continuance Intention being a function of Satisfaction and Task-Technology Fit. Educational divisions in organizations and firms should focus on making sure potential learners know and are informed of what the LMS can provide to the user, along with how much effort the user is expected to give when using the software. Investments in tutorial sessions or training seminars would impact continuance intention. Furthermore, LMS developers should focus on making the software as enjoyable as possible with a focus on simple hedonic pleasure, making the software as enjoyable, interesting, and fun as possible. Particular technology must be used on particular tasks. Specialized software would hold greater continuance intention than a one-size-fits-all approach in education.

Unfortunately, there are some limitations to this research. This research had a majority response rate of college-educated females, which limits the applicability of the research for future workforce demographic shifts. Future work using our model on the

different or more specific forms of LMS should also be performed due to the ever-changing nature of educational technology. Our analysis should also be expanded with the inclusion of more factors from other theories and models.

A longitudinal analysis and time-series studies on the continuance intention of LMS would further expand and support the theories proposed by this work. However, we hope that the findings of the research could be helpful for the development, adoption, and continuation of LMS in a world beyond the pandemic and encourage lifelong learning. We also suggest investigating the factors involved in these constructs, such as government support and organizational support

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## **Factors Influencing Restaurants on Selecting Food Delivery Applications**

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### **ABSTRACT**

The purpose of this thesis is to study factors influencing restaurants on selecting food delivery applications. This is quantitative research that adapts the Unified theory of acceptance and use of technology: UTAUT, factors from past research, and new factors, which are a business partner and the innovation expectations, all of these factors are used as a guideline for the research. This research studies a sample group of restaurant owners that use or have used food delivery applications for their business. The size of this sample group is 259 restaurant owners, the information is gathered by using an online poll, and the information is then analyzed by a program to see the relations of each factor according to the theory and guideline.

The result of the research indicates that relative advantage, business partners, Innovation Expectations, and trust in provider all directly influence the intention of using food delivery applications, while performance expectancy, Effort Expectancy, social influence, and Attitude Toward Use and Technology do not influence the intention of using food delivery applications.

*Keywords:* UTAUT, partner, innovation expectations, food delivery.

### **INTRODUCTION**

From the expansion of the food delivery business in Thailand that has increased significantly, Thai people have the habit of being in their comfort zone and with the coronavirus 2019 (COVID-19) epidemic. The government sector has taken various measures to prevent the spreading of the virus, among which includes the social distancing causing restaurant operators to be greatly affected by this crisis. Therefore, restaurant operators have increasingly begun to adapt to food delivery in order to expand the channels of services. The competition among food delivery service platform providers is varied from setting a low starting delivery price to not charging for delivery at all if the distance ordered is not more than that specified by the service provider or expanding the service delivering area to be more inclusive. As a result, the service users (consumers) gain more convenience. However, some of the food delivery service platform providers (Food Delivery) are still charging food operators on a percentage of sales or from gross profit, while some service providers pay more attention to food operators and do not focus on share of sales. These providers will increase delivery costs instead to provide more options for food operators.

Based on past research by Lee, Lee, and Jeon (2017), who studied the factors that influence behavior in using food delivery applications by examining the relationship between the factors of customers' reasons to use food delivery applications. By using an extended technology adoption model to explore the consumer experience of using food delivery through mobile applications which study in the context of consumers (people who use applications for ordering food), it is found that users generated data, providers generated data, and quality of application has a significant effect on the customers. Apart from that, the feature and design of the application and convenience of usage will have a significant effect and, in return, will benefit in users experience toward mobile applications (Prabowo and Nugroho (2019). While the internet is rapidly growing in Indonesia, Indonesians tend to engage in various activities on the internet and other supportive applications. Many Indonesians like to use online stores because they provide more convenience and economical value than traditional shopping channels.

This also happens in the food and beverage sector, which has spurred the emergence of online food delivery services. (Online Food Delivery). This study aimed to examine the influence of facilitation motivation and post-utilization benefits and other factors on attitudes toward online food delivery. It focuses on behavioral by online food delivery service with a mobile application case study of Go Food. Examples of this study included Go Food users in different regions in Indonesia supported by Go Food servicing areas. The results of this study show that behavioral attitudes and intentions toward the Go Food app are determined by perceived benefits, while its benefits are received from outward factors, i.e., motivation from cooking and time-saving.

From the above information, it was found that there have been extensive studies and research on service users (People who use apps to order food). The researcher considered that online food delivery service providers could be divided into three groups of users. The researcher, therefore, presents the research in the context of restaurant operators to study the factors influencing restaurants in choosing a food delivery service provider application by using the Unified Theory of Acceptance and Use of Technology (UTAUT). Apart from this, the researcher also studied Performance Expectancy, Effort Expectancy, Social Influence that affects Attitude Toward Use, and Technology. The researcher also added the business alliance factor of service providers and innovation expectations from entrepreneurs in choosing food ordering service providers as a guideline for improving, modifying, or developing their applications. The study is divided into four main objectives: 1) To study the factors influencing restaurants in choosing a food delivery service provider application by applying the technology integration theory (UTAUT) that

includes performance expectations, user effort expectations, social influence, including attitude factors towards the use, and technology and comparative benefits. 2) To study the influence of performance expectations, user effort expectations, social influence, trust in service providers, and comparative benefits affect attitudes towards use and technology. 3) To study the influence of service provider partners on intentions in choosing a delivery service provider application. 4) To study the influence of innovation expectations on intentions in choosing a food delivery service provider application.

### LITERATURE AND RELATED RESEARCH

In this research, the researcher studied the data in both academic articles and documents, as well as research studies related to factors influencing restaurants in choosing a food delivery service provider application. The data obtained will be used to formulate research hypotheses and design tools for further research. The researcher presented a literature review under the topic.

The unified theory of acceptance and use of technology (UTAUT) was presented by Venkatesh, Morris, Davis, and Davis (2003), which combines several accepted behavior theories to reduce the limitations of each theory and increase efficiency in research studies. The UTAUT shows that there are three factors. *Performance Expectancy*, the degree to which a person believes that the use of information systems will increase performance at work results in better work (Venkatesh *et al.*, 2003) or believes that the use of information systems will increase the benefits of work (Magsamen-Conrad, Upadhyaya, Joa, & Dowd, 2015) which is consistent with what Viswanath and Tse (2003) have defined and described. Performance expectation refers to how users feel that the technology can shorten the turnaround time and be beneficial. This factor is similar to the perceived benefit from the Technology Acceptance Model (TAM), which influences the attitudes of individuals affecting the use of information systems (Davis, 1989). *Effort Expectancy* is the level of ease of use of the technology (Venkatesh *et al.*, 2003), or the ease of learning, knowing, and understanding. It doesn't take too much effort to use technology (Sair & Danish, 2018), while Catherine, Geoffrey, Moya, and Aballo (2018) said that most technology users prefer technology that is flexible, useful and easy to use, and doesn't take much time to understand which will lead to acceptance and use. Several studies have been carried out, such as studies on the intention to use biometric authentication in financial transactions. *Social Influence* affects user decisions such as friends or family members (Venkatesh *et al.*, 2003) or when users feel insecure in using the service. Users are more likely to use social networks to help with decision-making (Song, Baker, Wang, Choi, & Bhattacharjee, 2018), in line with environmental and situational factors, knowledge, and other factors. In addition, person-to-person influence factors, environmental and behavioral factors are related in nature in a reciprocating manner (Bandura, 1977, 1986). Moreover, Wang, White, Chen, Gao, Li, and Luo (2015) examined an empirical study of the adoption of wearable technology in the field of health care found that social influence directly influenced the willingness to adopt wearable technology significantly. This is consistent with Wills, El-Gayar, and Bennett (2008), who studied the acceptance of electronic medical records in a group of physician assistants, nurses, and nursing assistants. It was found that social influence by users who perceived the importance of electronic medical records from the opinions of others played a significant role in intention to use the system. This is in line with the research of Im, Hong, and Kang (2011), which examined the international comparative acceptance of technology by studying the acceptance of online banking technology and MP3 players. The research found that social influence directly and positively influenced the user's willingness to use the system. All three factors directly affect behavioral intention, while the environmental factor supports it. Facilitating Conditions and Behavioral Intention directly affect user behavior.

The characteristic factor of innovation, Rogers (2003), states that the process of adoption of innovation is the decision to accept that innovation and implement it or is most useful. Moore and Benbasat (1991) adopted the concept of innovation from the theory of perception by properties. It is one of the most popular core components of the DOI theory to study the behavior of individuals using technology (Greenough, Black, & Wallace, 2002; Cheung & Chan, 2000), Trust in Provider, and Attitude Toward Use and Technology.

Trust in Provider Luhmann (1968): Trust is generally an important factor in social interactions that involves uncertainty. Trust is, in part, shown to be a mechanism that simplifies human behavior in uncertain situations in line with what Gefen, Karahanna, and Straub (2003). Gefen and Straub (2004) say that credibility is the core to any economic transaction, while Grabner-Kraeuter (2002) states that one key reason for its importance is the fact that in a virtual environment, the degree of uncertainty of economic transactions on the internet commerce is higher than that of traditional settings. This can pose a number of risks that may arise from uncertainty. It can be explained by the behavior of users engaged in online transactions while trusting the service provider is the user's belief with trust in service providers, to be honest. Serviceability (Rotter, 1967; Morgan & Hunt, 1994; Bhattacharjee, 2002; Warkentin, Gefen, Pavlou, & Rose, 2002) is consistent with Corbitt, Thanasankit, and Yi (2003); Teo and Liu (2007), who said that the reliability of the service provider plays an important role in the exchange of relationships between service users and service providers.

Attitude Toward Use refers to the user's attitude as a result of perceived ease of use and perceived usefulness. Awareness of the usefulness or efficiency of the system and its level of ease of use. Users develop a positive attitude towards a system or technology and affect their willingness to use that system or technology (Azjen, 1980) to the decision-making and behavior of service users. Trust in technology is an important component of trust theory (Li, Rong, & Thatcher, 2012) which is inconsistent with research showing that Attitude Toward Use and Technology has a positive effect on the intention to use of the system (Prabowo and Nugroho, 2019; Chen *et al.*, 2020; Asnakew, 2020; Nor *et al.*, 2008). While the business partner (Partner / Alliance) Lambe, Spekman, and Hunt (2002) gave a meaning of "Business Partner" as a cooperative relationship between two or more organizations, both parties have wishes or goals to achieve the objectives of doing business together.

The purpose of this research was to synthesize a model based on the previous theory in order to understand and summarize the correlation of each of the interrelated factors of intention to use food ordering service through the customer application in Thailand by studying from service providers (Grab, Line Man, Food Panda, Gojek and Robinhood).

**RESEARCH FRAMEWORK**

From the theory and research that affects the intention of using food delivery service provider application, it can be seen that Performance Expectancy, Effort Expectancy, Social Influence, Relative Advantage, Trust in Provider, and Attitude Toward Use and Technology influence restaurants in choosing service provider application for food delivery. While Performance Expectancy, Effort Expectancy, Social Influence, Relative Advantage and Trust in Provider influence the Attitude Toward Use and Technology.

In this research, the researchers added factors to the conceptual research framework for use in the investigation, including Partner/Alliance influences restaurants in choosing the application. Intention to use the service to accept food orders of the application food delivery and Innovation Expectations influence restaurants to choose food delivery service provider application. The researcher presents the conceptual research framework in Figure 1.

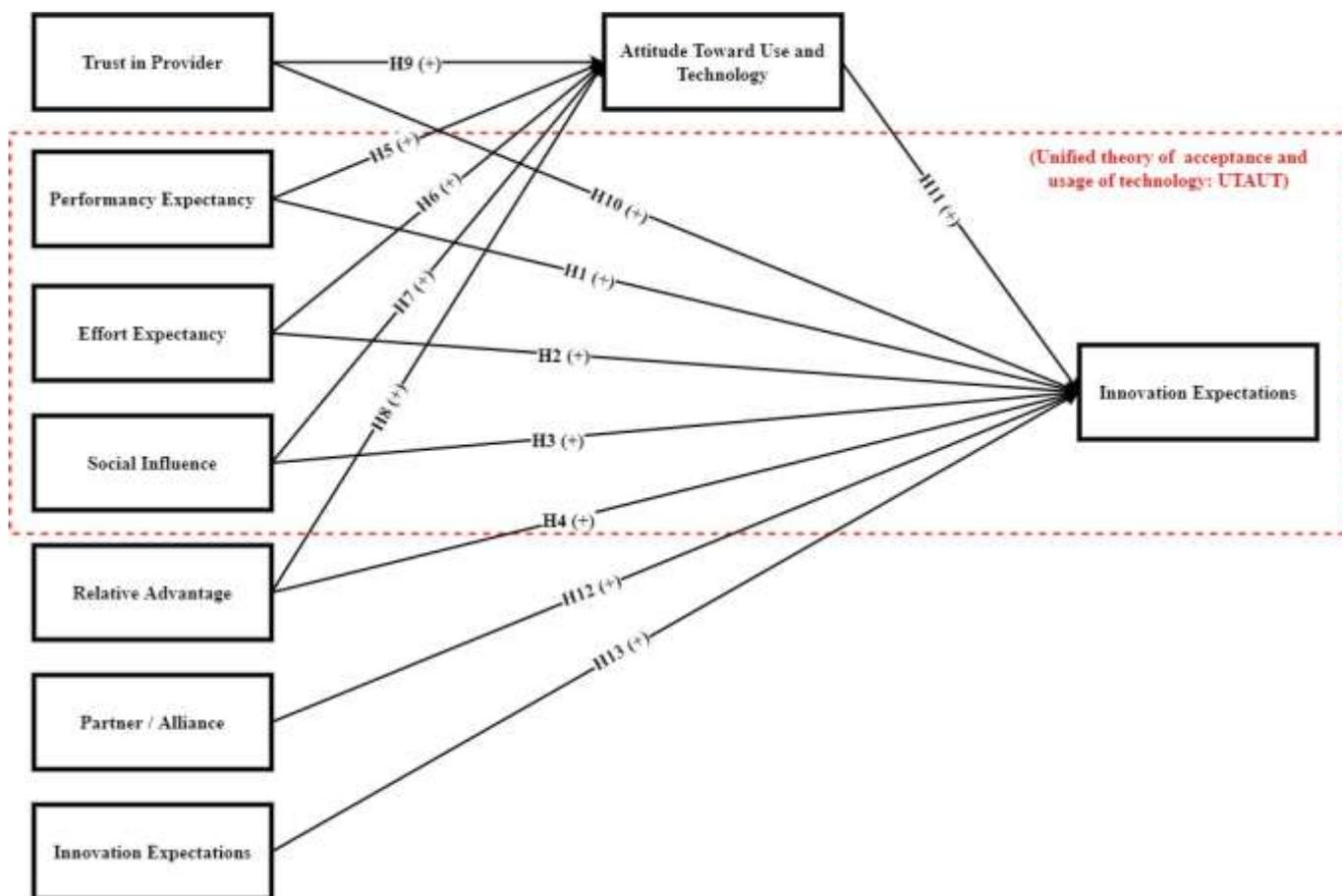


Figure 1: Conceptual framework.

**METHODOLOGY**

**Selection of samples and samples**

The purpose of the random sampling was used to target the main research group as a group of restaurant operators, whether it is street food, a small entrepreneurial restaurant, or restaurants that have outlets in Thailand. A total of 279 questionnaires were submitted and received a response that met the eligibility criteria of 259 research subjects.

**Research tools**

The researcher collects data through the distribution of online questionnaires. The questionnaire is divided into three sections: information about the food delivery order application; used for verifying the identity of the restaurant operator. In order to use the food delivery order application, respondents (restaurant operators), general information questions such as gender, age, education, the questions are in the form of Normal Scale by preparing the format of the exam as a checklist. A question about the opinions of a sample used to study the factors influencing restaurants in choosing a food delivery service provider application by using the assessment 5-level Likert Scale estimation ratio model (5 – strongly agree, 1 – strongly disagree).

**Analysis**

The questions were analyzed using exploratory factor analysis (EFA) for internal reliability through varimax rotation. We have found our results to be within acceptable ranges based on the literature review. We present the factor loading values in the table below.

Table 1: Exploratory factor analysis.

Construct	Item Description	Factor Loading
Performance Expectancy (PE)	PE2	0.763
	PE4	0.759
	PE3	0.741
	PE1	0.608
Effort Expectancy (EE)	EE4	0.834
	EE2	0.813
	EE3	0.796
	EE1	0.771
Social Influence (SI)	SI2	0.860
	SI1	0.859
	SI3	0.816
	SI4	0.625
Relative Advantage (RA)	RA1	0.841
	RA2	0.840
	RA3	0.833
	RA4	0.809
Trust in Provider (TP)	TP2	0.861
	TP1	0.818
	TP4	0.649
	TP3	0.605
Partner / Alliance (PA)	PA4	0.855
	PA3	0.828
	PA2	0.819
	PA1	0.806
Innovation Expectations (IE)	IE3	0.845
	IE4	0.802
	IE2	0.789
	IE1	0.712
Attitude Toward Use and Technology (AUT)	AUT4	0.763
	AUT2	0.751
	AUT3	0.751
	AUT4	0.711
Intention to use the service to accept food orders of the restaurant operators (INT)	INT4	0.868
	INT3	0.810
	INT1	0.793
	INT2	0.775

The questionnaire possessed relatively high Cronbach Alpha values, and all factors had Cronbach's alpha exceeding 0.7. This suggests that the measurement items were reliable. We present Cronbach's alpha values in Table 2.

Table 2: Cronbach's Alpha test results.

Construct	Cronbach's Alpha	Number of Questions
Performance Expectancy (PE)	0.757	4
Effort Expectancy (EE)	0.842	4
Social Influence (SI)	0.856	4
Relative Advantage (RA)	0.893	4
Partner / Alliance (PA)	0.868	4
Innovation Expectations (IE)	0.875	4
Trust in Provider (TP)	0.751	4
Attitude Toward Use and Technology (AUT)	0.811	4
Intention to use the service to accept food orders of the Restaurant operators (INT)	0.850	4

### Hypothesis testing

Then performed a regression analysis on the hypotheses defined by the conceptual framework. We illustrate our findings in the following figure. We observe in our regression analysis that all our values for the Standardized Coefficient  $\beta$  were positive, which suggests that our model was quite accurate in predicting a positive relationship between the variables of the three models. However, some hypotheses were not supported by the regression analysis at the desired significance level.

Table 3: Hypothesis testing.

Hypothesis	Conclusion	Standardized Coefficient $\beta$
H1 (Performance Expectancy $\rightarrow$ Intention to use)	Not Supported	-0.058
H2 (Effort Expectancy $\rightarrow$ Intention to use)	Not Supported	0.050
H3 (Social Influence $\rightarrow$ Intention to use)	Not Supported	0.016
H4 (Relative Advantage $\rightarrow$ Intention to use)	Supported	0.183*
H5 (Performance Expectancy $\rightarrow$ Attitude Toward Use and Technology)	Supported	0.227*
H6 (Effort Expectancy $\rightarrow$ Attitude Toward Use and Technology)	Not Supported	0.075
H7 (Social Influence $\rightarrow$ Attitude Toward Use and Technology)	Supported	0.170*
H8 (Relative Advantage $\rightarrow$ Attitude Toward Use and Technology)	Supported	0.135*
H9 (Trust in Provider $\rightarrow$ Attitude Toward Use and Technology)	Supported	0.362*
H10 (Trust in Provider $\rightarrow$ Intention to use)	Supported	0.174*
H11 (Attitude Toward Use and Technology $\rightarrow$ Intention to use)	Not Supported	0.116
H12 (Partner / Alliance $\rightarrow$ Intention to use)	Supported	0.118*
H13 (Innovation Expectations $\rightarrow$ Intention to use)	Supported	0.298*

\*  $p < .05$

It was found that the independent dependency variable in trust in provider had a significance  $p$  less than 0.05, indicating acceptance of the hypothesis line. and the regression coefficients (beta) were 0.362, 0.277, 0.170 and 0.135, respectively. The independent variables that had the highest influence on attitudes towards use and technology were: trust in providers with a regression coefficient (beta) of 0.362 ( $p = 0.000$ ). Furthermore, the variable that had the highest influence on the intention to use

was the Innovation Expectations variable with a regression coefficient (beta) of 0.298 ( $p = 0.003$ ). While Performance Expectancy, Effort Expectancy, Social influence and Attitudes toward use and technology There is no direct influence on the intention of use.

## DISCUSSION

However, hypothesis 1,2,3, which is the main theory used by the researcher, is not supported in which Wong, Muhammad, and Abdullah (2020) found a similar insignificant correlation in research on the intention to use whiteboards in the interactions of university students in Malaysia. Whether the efficiency of technology is important or not, the results of the study concluded that students believe that the use of interactive whiteboards is not effective enough to help them in their studies, resulting in no intention of using them. Meanwhile, Effort Expectancy did not affect the intention to use because, in Thailand, restaurant operators are alert and change the style of food sales from selling only on-premises. With the effect of the coronavirus (COVID-19) epidemic, they are in the process of starting to use food ordering services through a service provider application. They need to register, verify identity through the application. This may cause concern for some restaurant operators. Social Influence is consistent with Hino (2015) studying the intentions of internet users to use biometric technology. It was found that the intention was not due to the influence of people around them or the media, and not the feeling that using the application will look more modern than those who do not use it. Unlike hypothesis shows that Partner/Alliance and Innovation Expectations influence the intention of using food ordering service provider application. The level of satisfaction that users of the services will build confidence, increased reliability for accuracy will have a positive effect on the intention of using the service for food orders through the service provider application. Restaurant operators believe that service providers will then develop new technologies or services that help increase work efficiency for users resulting in satisfaction for customers or service recipients

## RESEARCH SUMMARY

The purpose of this research was to study the factors influencing restaurants in choosing a food delivery service provider application by applying the Unified theory of acceptance and usage of technology (UTAUT) and the theory of Diffusion of Innovation (DOI) and past factors, including Attitude Toward Use and Technology, as well as adding new factors used in the study, including Partner / Alliance and Innovation Expectations, to test research hypotheses.

Statistical analysis results on the influence of factors affecting restaurants in choosing a delivery service provider application. It was found that restaurant operators' decision to order food service was influenced by Relative Advantage, Trust in Provider, Partner/Alliance, and Innovation Expectations factors affecting their intention to use the service provider application. food delivery

The results of this research Can be used to support food delivery service providers in application development. To know and access the factors that influence restaurants to choose a food delivery service provider application. And can use the information for further study to prepare for the development of services or technologies used in Thailand's applications in the future to meet the target groups that result in an increasing trend.

Recommendations. This study examined the factors that influence restaurants to choose food delivery applications. It does not include accepting food ordering users and food delivery drivers to service providers.

The researcher is of the opinion that additional theories and factors should be studied from the perspective of service users to order food through the service provider application or the view of the food delivery man. Future research can lead to Unified Technology Adoption and Use Theory (UTAUT), including alliance/alliance factors and innovation expectations. In this research, restaurant operators were analyzed. To analyze from the perspective of service users in ordering food or food delivery man. By studying the factors affecting the use of food ordering services through the service provider application from the perspective of the service user or the point of view of the food delivery person to study and compare the opinions of service users or food delivery service providers to see what factors affect Intent to use it to increase understanding of user behavior. Further research can be further enhanced by analyzing the intentions of using food ordering services through each restaurant operator's service provider application. For example, large restaurant operators are more likely to choose one provider over the rest for any reason.

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## Helping Beginning Vloggers to Overcome Cold Start: the Perspective of Identity Construction

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### ABSTRACT

Beginning vloggers' low enthusiasm for Vlog creation has garnered little consideration, even though a social media platform can highly improve user stickiness and user activity by engaging users to generate content. This paper investigates the effects of extrinsic and intrinsic motivations on Vlog creative behavior mediated by cognition and emotion based on social cognitive theory and self-discrepancy theory. The analysis of 342 questionnaire surveys shows that intrinsic motivation (social interaction and social cues presentation) positively affects identity construction and positive emotions. In contrast, extrinsic motivation (community incentives and social norms) only positively affects identity construction and does not significantly influence positive emotions. Identity construction and positive emotions further significantly affect the creative behavior of beginning vloggers. The results reveal the process of Vlog creative behavior and have important practical implications for enhancing the platform performance.

*Keywords:* Vlog, beginning vloggers, creative behavior, identity construction.

### INTRODUCTION

The popularity of user-generated content has hugely changed the market structure from being ruled by traditional media to empowering consumers to be an influencer (Al-Debei et al., 2013; Ye et al., 2021). Among great forms of UGC, Vlog ( Video Blog ) attracts more and more consumers to watch and engage due to its rich content creation space. A survey conducted by Iimedia (2021) reported that the user of Vlogs in China has grown to 368 million by 2020 and is expected to reach 488 million in 2021. Internet industry leaders also notice this promising market prospect and invest in the short video segment. Some short video platforms, such as TikTok, have soon become globally popular.

Though the rapid growth of social media platforms provides effective channels for Vloggers to locate a position and engage, video creation still has a long-tail effect. Only a tiny subset of viewers converts to creators. Among those creators, only a few people can keep on (Sun et al., 2014). The famous '90-9-1' principle states that 90% of participants only view Vlogs, 9% of participants may try to post some videos, only 1% of the participants actively upload new content. Therefore, 99% of users in the Vlog community belong to beginning vloggers (Garfield, 2020), and how to motivate users to create has become an issue of concern.

Previous studies mainly focused on the users' motivations to view Vlogs (Kang & Cho, 2020) and influencer marketing (Coates et al., 2020; Lewis, 2020) and indicated user self-presentation, expression management, and gaining recognition from others encouraged users to create Vlogs. However, there remains a gap in the motivation of beginning Vloggers' creative behaviors in academics. Actually, understanding antecedents of creative user behavior are conducive for beginning vloggers to generate content, further improving the popularity and stickiness of short video platforms (Munnukka et al., 2019), and practitioners have already run many marketing campaigns and offered generous material rewards to call for high-quality Vlogs, but external stimuli and internal motives are rarely taken into account in creative user behavior simultaneously.

To fill the gap, we combine both extrinsic motivation and intrinsic motivation of beginning Vloggers into our model. Besides, previous studies illustrated that cognition and affection mediated the relationship between stimuli and user behaviors (Hollebeek et al., 2014). That is, the user behavior is affected by subjective and objective judgment. Therefore, based on self-discrepancy theory and social cognitive theory, the research questions are as follows: 1) What extrinsic and intrinsic motivations drive users to convert to Vloggers and insist on creating? 2) From cognition and affection, what is the mechanism behind this behavior?

### LITERATURE REVIEW

### **Vlog's creative behavior**

Vlog, short for the video blog, is a new type of users' self-publishing content. Unlike traditional video content, Vlogs offer viewers insight into Vloggers' private life and add specific intrinsic characteristics by clipping. Typically, the content length is shortened by two orders of magnitude, and so is the production time. Successful Vloggers can often be identified as expertise, intimate, and authentic (Hudders et al., 2021). They are skilled in the complete process of video production and creating meaningful parasocial relationships with viewers (Ye et al., 2021). Some are even endorsed by professional agencies. Research on YouTube influencer marketing has flourished in the past few years (Kim & Kim, 2021). However, a huge body of Vloggers is common consumers facing a cold start in the early stage of video creation. Undergoing a cold start in the Vlog community context can be referred to as a state of lack of motivation for creation at the beginning stage. Helping beginning vloggers to overcome cold start becomes essential for platforms.

### **Self-discrepancy theory and Identity construction**

The self-discrepancy theory was originally proposed by Higgins, indicating different types of discrepancies between self-state representations are related to emotional vulnerabilities. According to self-discrepancy theory, self-state representation consists of three domains: actual self; ideal self; should make self. The actual self is the identity that an individual actually possesses, representing the individual's self-concept, ideal self reflects hopes and desires to possess, and should self refers to duties, responsibilities, or obligations to possess. Discrepancies between the actual/own self-state and ideal self-states are called self-difference, signify the absence of positive outcomes, which is associated with dejection-related emotions (Higgins, 1987).

In the real world, achieving consensus between actual self-representation and ideal self-representation is difficult, especially when the standpoint of ideal self-presentation is on others. Fearing below the expectation of people around will lead to negative emotions such as disappointment, dissatisfaction, and sadness (Higgins, 1989). However, it's time and energy-consuming to meet the expectation of people around in all aspects of real life. Besides, as influencer culture becomes dominant, comparing one's life with the influencer's life often results in an unfavorable social comparison, indicating that the influencer's life is perceived as superior, resulting in envy (Chae, 2018). Only a limited number of people can live a luxurious life in real-world like influencers. The virtual world provides an opportunity for common users to remodel identity and ease the conflict between self-representation discrepancies (Huang et al., 2019). Users can grow feelings of high esteem and perceive higher social value in social communities by reconstructing a virtual identity.

Unlike other traditional online communities such as Weibo, short video platforms need participants to consume more time and energy to shoot and edit videos. The cost to view and create a video weakens the bond between friends and makes it difficult to become a tool to involve continuous interaction with friends. Thus, strangers who watch Vlogs to entertain themselves become key audiences. Vloggers can easily hide stereotypes in real life and reconstruct ideal identities.

### **Social cognitive theory and motivation to contribute UGC**

Social cognitive theory, first proposed by Bandura (Bandura et al., 1989), consists of three dimensions: environment, individual, and behavior. It illustrates that human functioning is rooted in social systems and holds the view that individual behavior is partially shaped and controlled by the social environment (i.e., social system) and individual's cognition (such as expectations, beliefs). In other words, individual creates social systems to organize, guide, and regulate human activities, and motivation has been a prominent feature of social cognitive theory. Therefore, the social cognitive theory is one of the most effective theories to explain individual behavior, emphasizing behavioral, extrinsic, and intrinsic influences' reciprocal interactions on motivation in the social learning process (Schunk & DiBenedetto, 2020).

According to social cognitive theory, the factors that motivate users' creative behavior can be considered as the environment faced by users. Previous studies about motivation to contribute to UGC can be divided into two categories: extrinsic and intrinsic. For extrinsic motivations, Chen et al. (2010) found that comparing with peers can significantly increase contribution to an online community. Some explicit incentives, such as monetary incentives and normative pleas, will both have drawbacks in the long term (Garnefeld et al., 2012; Liu et al., 2016). Though receiving monetary incentives, Garnefeld et al. (2020) showed that reviewers would insist on writing negative reviews to resist marketers' influence. Combining explicit incentives and social norms proves to yield the greatest overall benefits to creative behaviors (Burtch et al., 2018). For intrinsic motivations, Previous studies on intrinsic motivations mainly focused on altruistic needs (Reimer & Benkenstein, 2016; Yang, 2017), self-enhancement (Taylor et al., 2012), self-affirmation (Alexandrov et al., 2013), hedonic needs (Yoo & Gretzel, 2011).

Vlogs, compared with other types of UGC, present more private information about creators. Social cues embedded in Vlogs can be an important antecedent of identity construction resulting in creative behaviors which may be insignificant in other contexts. The para-social relation is usually used to explain part of the persuasive appeal of influencer marketing (Sokolova & Kefi, 2020). Instead of obligation or responsibility, fantasy and imagination stimulate fans to remain involved in the para-social relation with idols. Previous studies often start from the perspective of fans to study para-social relations (Daniel Jr et al., 2018). However, the para-social relation needs from creators are much less researched. It's hard for beginning Vloggers to make a profit from generating the content. To some extent, interaction with viewers and building para-social relations can largely encourage Vloggers to insist on.

## MODEL DEVELOPMENT AND HYPOTHESES

As Figure 1 presents, the formation of Vlog creative behavior proceeds in three stages. First, extrinsic factors (community incentives and social norms) and intrinsic factors (social cues presentation and social interaction) simultaneously result in changes in the users' cognition (identity construction) and emotion (positive emotion). Cognition and emotion further lead to changes in behavior (intention to create Vlog). According to social cognitive theory, constructs in the first stage can be considered as a specific environment faced by users. Two mediators in the second stage represent individual reactions when facing the environment. Vlog creative behaviors are the final result of the interaction between environment and individual.

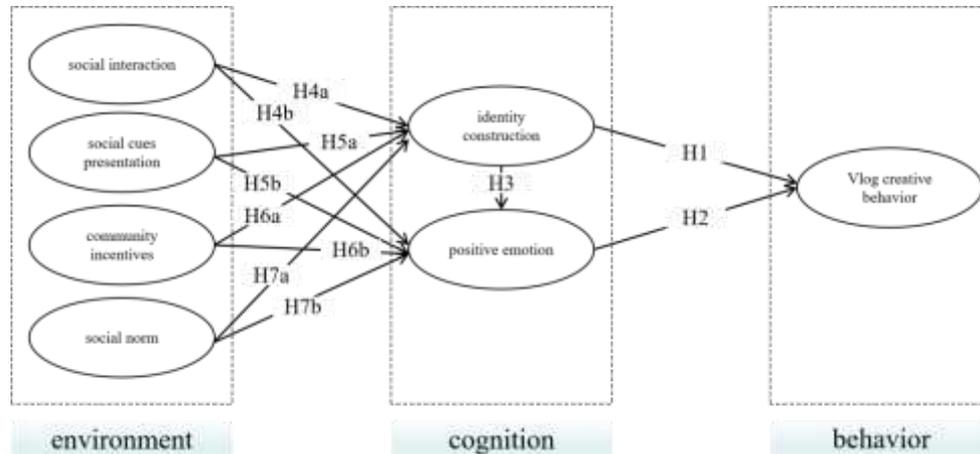


Figure 1: The research model.

### Identity construction and Vlog creative behavior

Identity construction is a process involving dynamic subjective and objective evaluation. Only when subjective positioning from self and perceived objective positioning from others reach a consistency can one construct identity (Zhao et al., 2008). In the real world, achieving consensus between actual self-representation and ideal self-representation is difficult, especially when the standpoint of ideal self-representation is on others. The virtual world provides an opportunity for common users to remodel identity and ease the conflict between self-representation discrepancies (Huang et al., 2019). Through the later editing, users can show the life picture they are willing to perform in a short video and effectively form an ideal self-presentation without too much cost. Therefore, we propose the following hypothesis:

H1: Identity construction is positively related to Vlog creative behavior.

### Positive emotion and Vlog creative behavior

According to self-discrepancy theory, the discrepancy between actual and ideal or should self-presentation will lead to different negative emotions. Barnett et al. (2017) indicated that the discrepancy between actual and ideal self-presentation could be an efficient predictor for individual emotion. As mentioned above, the narrowing gap between actual self-presentation and ideal self-presentation can promote cognitive consistency, relieving negative emotions. In addition, as an emotional state, positive emotions can influence behavioral intentions of engaging (Hollebeek et al., 2014). Wang et al. (2017) indicated that positive emotion promotes users' urge to share information on microblogs. Therefore, we propose the following hypothesis:

H2: Positive emotion is positively related to Vlog creative behavior.

H3: Identity construction is positively related to positive emotion.

### Social interaction and intrinsic cognition

One of the essential features of social networking sites is that users spread information through social interaction. Social interaction brings a communication bond in the virtual community, representing more potential replies and compliments, thereby enhancing intrinsic self-esteem and self-identity (Cheng & Guo, 2015). Vlog creators present their information in videos and express themselves to gain interactive communication with other users. Social interaction through Vlogs is mainly carried out through various functions such as comments, likes, following, and bullet screens. Through these interaction indicators, creators can have a deeper understanding of themselves and constantly seek recognition of others in Vlog creation to enhance their reputation and status in social networks. Finally, to complete identity construction. At the same time, the interactive forms in the Vlog community are gradually diversified, enabling creators to obtain spiritual satisfaction and material satisfaction (Wang et al., 2017). Therefore, we propose the following hypothesis:

H4a: Social interaction is positively related to identity construction.

H4b: Social interaction is positively related to positive emotion.

### **Social cues and intrinsic cognition**

Social cues include demographic information (e.g., age) or intrinsic characteristics (e.g., appearance). Social platforms allow users to provide basic intrinsic information on the homepage. Such information may be inauthentic because of fewer social cues with brief texts and pictures. Conversely, a Vlog involves multiple social cues, fully disclosing the vlogger's appearance, characteristics, and environment, with a certain authenticity and diversity. Hong et al. (2020) found that the presentation of the social cue in selfies increases users' self-expression and impression management. Therefore, the presentation of high social cues plays a positive role in the construction of creator identity. Besides, social cues presentation can be used to predict interpersonal relationships and social support. UGC with more social cues can encourage more interaction, thereby promoting happiness (Luo & Hancock, 2020). Accordingly, the richness and authenticity of information cues increase the possibility of others' identity and self-identity, and self-disclosure directly affects positive emotion. Therefore, we propose the following hypothesis:

H5a: The social cues presentation is positively related to identity construction.

H5b: The social cues presentation is positively related to positive emotion.

### **Community incentives and intrinsic cognition**

External incentives are also crucial for creative behavior. At present, Vlog creation not only meet the needs of social interaction but also allows authors to obtain financial benefits. The incentives provided by the platform for vloggers include material rewards (e.g., cash) and virtual rewards (e.g., badges, titles, and specific titles). Virtual rewards that represent the platform's recognition of users can be displayed to others, helping to enhance intrinsic social identity (McMillan & Hwang, 2002). Therefore, community incentives can enhance users' sense of honor and self-esteem, providing opportunities for identity construction.

The rewards of the virtual community can also increase the sense of pleasure and self-efficacy, which in turn affects the degree of knowledge sharing of virtual community members (Goes et al., 2016). For Vloggers, it takes more energy and time to shoot and post-process. Material rewards can stimulate the vlogger's positive emotions, affecting the creator's community engagement. Therefore, we propose the following hypothesis:

H6a: Community incentives are positively related to identity construction.

H6b: Community incentives are positively related to positive emotion.

### **Social norm and intrinsic cognition**

Social norms refer to the prevalence of behavior in a relevant population, which are conducive to the establishment of their own identity image. For example, Burtch et al. (2018) investigated that social norms had a positive effect on the production of online reviews. Chen et al. (2010) found that comparing with peers can significantly increase contribution to an online community. In the creative atmosphere, users of a platform will perceive that it is a common trend to create and share Vlog. Especially when seeing people who influence them are sharing and creating Vlogs, individuals tend to imitate their behaviors to increase the likelihood of recognition and maintain their own identity.

Besides identity construction, social norms are closely linked to emotion and mood. Zhang et al. (2017) indicated that social norms positively affected users' sense of pleasure and made them believe that other members of the community were also willing to abide by norms and share knowledge. Huang et al. (2013) proposed that social norms may affect the behavioral intention by changing the individual's emotions towards the knowledge-sharing behavior. Actually, when feeling that peers are creating Vlogs, users can enhance positive emotions such as pleasure. Therefore, we propose the following hypothesis:

H7a: Social norms are positively related to identity construction.

H7b: Social norms are positively related to positive emotion.

## **METHODOLOGY**

### **Data collection**

The data were collected from students studying in a public university in Southwest China from October 2020 to November 2020. All latent variables were measured by using 7-point Likert scales (1=strongly disagree to 7=strongly agree). Vlog creation was measured with four items developed by Farooq et al. (2014). Identity construction was measured with six items from Rosenberg et al. (1989) and Rosenthal et al. (1981). Positive emotion was assessed using four items adapted from Beatty and Ferrell (1998). The extrinsic motivation was measured using two dimensions: community incentive and social norm. Each dimension of extrinsic motivation was evaluated using five items developed by Morhart et al. (2009) and Al-Debei et al. (2013). Intrinsic motivation was measured using two dimensions: social cues presentation and social interaction. Social norm was measured with five items drawn from Fishbein and Ajzen (1977) and Al-Debei et al. (2013). Social cues presentation was evaluated using five items developed by Morhart et al. (2009). A screening item (e.g., How many Vlogs have you published?) was used to ensure whether participants are beginning Vloggers. Using this screening item, respondents who had published Vlogs less than ten participated in the survey. Finally, the questionnaire is designed into two sections: the first section collects the demographic profile of respondents. The second section collected the participants' responses to our research variables.

Exam Star, a platform providing functions equivalent to Amazon Mechanical Turk, was used as the platform software for a survey. The online survey returned a total of 428 responses indicating that they were beginning Vloggers. However, upon further inspection, a total of 86 responses were removed due to conflicting or missing responses. Demographic results indicated that there were 147 males (43%) who responded to the survey. Slightly more than half (53.5%) of respondents were born between 1995-2002. The majority (60.2%) of respondents had at least some college education.

## Data analysis

### Confirmatory factor analysis(CFA)

In this study, we conduct confirmation factor analysis to assess the validity and reliability of the measurement items. As shown in Table 1, Composite Reliability (CR) and Cronbach's alpha (CA) for all observed variables both exceeded 0.80, indicating ideal reliability. The average variance extracted (AVE) by each latent variable was above the 0.50 threshold (Fornell & Larcker, 1981). In short, convergent validity was achieved. Discriminant validity was checked by calculating the squared correlation between variables. The results revealed that the correlation coefficients between the variables were less than 0.60, and the square roots of the AVE of each variable are larger than the correlation coefficients with other variables. Hence, discriminant validity was also achieved. Besides, the factor loading of each item on the corresponding latent variable was higher than that on other latent variables, also indicating that it had good discriminant validity.

Table 1: Confirmation factor analysis.

	IC	CI	SN	PE	SCP	VCB	SI	CA	CR	AVE
SI1	0.123	0.169	0.042	0.192	0.152	0.080	<b>0.764</b>	0.85	0.857	0.601
SI2	0.126	0.105	0.023	0.187	0.056	0.025	<b>0.831</b>			
SI3	0.059	0.069	0.165	0.060	0.082	0.133	<b>0.857</b>			
SI4	0.114	0.011	0.229	-0.006	0.043	0.101	<b>0.723</b>			
SCP1	0.152	0.090	0.143	0.081	<b>0.764</b>	0.074	-0.004	0.878	0.88	0.647
SCP2	0.177	0.081	0.057	0.150	<b>0.836</b>	0.109	0.074			
SCP3	0.106	0.087	0.219	0.061	<b>0.809</b>	0.070	0.124			
SCP4	0.070	0.133	0.087	0.182	<b>0.840</b>	0.089	0.151			
CI1	0.186	<b>0.839</b>	0.123	0.096	0.079	0.019	0.086	0.914	0.914	0.681
CI2	0.145	<b>0.833</b>	0.102	0.114	0.050	0.030	0.125			
CI3	0.142	<b>0.851</b>	0.115	0.104	0.100	0.060	0.089			
CI4	0.093	<b>0.825</b>	0.100	0.090	0.070	0.105	0.070			
CI5	0.129	<b>0.804</b>	0.027	0.020	0.114	0.173	0.004			
SN1	0.124	0.115	<b>0.776</b>	0.115	0.086	0.119	0.015	0.891	0.892	0.626
SN2	0.084	0.140	<b>0.753</b>	0.140	0.098	0.097	0.094			
SN3	0.132	0.083	<b>0.708</b>	0.030	0.220	0.098	0.185			
SN4	0.140	0.076	<b>0.868</b>	0.065	0.074	0.104	0.099			
SN5	0.092	0.052	<b>0.852</b>	0.094	0.075	0.164	0.116			
IC1	<b>0.781</b>	0.170	0.121	0.123	0.174	0.199	0.014	0.917	0.917	0.647
IC2	<b>0.785</b>	0.176	0.163	0.085	0.153	0.163	0.018			
IC3	<b>0.847</b>	0.068	0.115	0.038	0.037	0.178	0.022			
IC4	<b>0.817</b>	0.123	0.128	0.112	0.077	0.136	0.149			
IC5	<b>0.789</b>	0.181	0.046	0.149	0.073	0.047	0.157			
IC6	<b>0.727</b>	0.089	0.087	0.192	0.127	0.066	0.168			
PE1	0.130	0.092	0.126	<b>0.807</b>	0.149	0.130	0.166	0.889	0.888	0.665
PE2	0.188	0.090	0.103	<b>0.786</b>	0.141	0.184	0.172			
PE3	0.142	0.129	0.120	<b>0.834</b>	0.098	0.179	0.040			
PE4	0.142	0.104	0.095	<b>0.779</b>	0.107	0.186	0.077			
VCB1	0.209	0.104	0.164	0.192	0.175	<b>0.750</b>	0.096	0.891	0.892	0.673

VCB2	0.174	0.083	0.101	0.157	0.022	<b>0.843</b>	0.098			
VCB3	0.195	0.125	0.207	0.170	0.058	<b>0.807</b>	0.076			
VCB4	0.131	0.084	0.137	0.180	0.130	<b>0.793</b>	0.107			

Note: CA=Cronbach's alpha, CR=Composite Reliability, AVE=average variance extracted, SI= Social interaction, SCP= Social cues presentation, CI= Community incentive, SN= Social norm, IC= Identity construction, PE= Positive emotion, VCB= Vlog creative behavior.

Table 2: Correlations matrix among the latent constructs.

	VCB	IC	PE	SI	SCP	CI	SN
VCB	0.820						
IC	0.479	0.804					
PE	0.518	0.424	0.815				
SI	0.328	0.313	0.378	0.775			
SCP	0.337	0.370	0.409	0.314	0.804		
CI	0.304	0.402	0.325	0.285	0.302	0.825	
SN	0.418	0.356	0.337	0.330	0.337	0.286	0.791

Note: The diagonal elements are the square root of variance shared between the AVEs, whereas the off-diagonal elements are correlations among constructs.

#### Common method bias

Common method bias, caused by the measurement method used in an SEM study, adversely affects the estimation of the research model. For example, the instructions at the top of a questionnaire may influence the answers provided by different respondents in the same general direction, causing the indicators to share a certain amount of common variation. Another possible cause of common method bias is the implicit social desirability associated with answering questions in a questionnaire in a particular way, again causing the indicators to share a certain amount of common variation (Kock, 2015). To eliminate the possibility of common method biases, we adopted Harman's single-factor test. The result reveals that the seven factors combined account for 73.37% of the total variance, and the largest factor accounts for 31.34% of it. This indicates that there is no general factor.

#### Hypothesis test

First, we checked the fitness of our structural model. All fit indexes performed well :  $\chi^2/DF=2.253$ , IFI= 0.923, TLI= 0.914, CFI=0.922 , RMSEA=0.61 . Table 3 presents the results for all path coefficients in the research model. Identity construction ( $\beta=0.319$ ,  $p < 0.001$ ) and positive emotion ( $\beta=0.391$ ,  $p < 0.001$ ) both had a significant influence on Vlog creative behaviors. These results support H1 and H2. Furthermore, identity construction showed a significant positive influence on positive emotion ( $\beta=0.207$ ,  $p < 0.01$ ). Thus, H3 is supported. Social interaction showed a significant positive influence on identity construction ( $\beta=0.121$ ,  $p < 0.05$ ) and positive emotion ( $\beta=0.188$ ,  $p < 0.01$ ). Thus, H4a and H4b are supported. Social cues presentation showed a significant positive influence on identity construction ( $\beta=0.195$ ,  $p < 0.01$ ) and positive emotion ( $\beta=0.21$ ,  $p < 0.001$ ). Thus, H5a and H5b are supported. The influence of community incentives on identity construction ( $\beta=0.258$ ,  $p < 0.001$ ) is significantly positive, but insignificantly on positive emotion ( $\beta=0.258$ ,  $p < 0.001$ ) (H6a supported , H6b not supported). The effect of social norm on identity construction ( $\beta=0.183$ ,  $p < 0.01$ ) is significantly positive, but insignificantly on positive emotion ( $\beta=0.112$ ,  $p = 0.059 > 0.05$ ) (H7a supported, H7b not supported).

Table 3: Standardized parameter estimates.

Hypothesis	Hypothesized path	Standardized estimate	S.E	C.R	P	Results
	identity construction → Vlog creative behavior	0.319	0.071	5.307	<0.001***	H1 Supported
	positive emotion → Vlog creative behavior	0.391	0.07	6.311	<0.001***	H2 Supported
	identity construction → positive emotion	0.207	0.066	3.261	0.001**	H3 Supported
	social interaction → identity construction	0.121	0.064	2.027	0.043*	H4a Supported
	social interaction → positive emotion	0.188	0.068	3.09	0.002**	H4b Supported
	social cues presentation → identity construction	0.195	0.048	3.235	0.001**	H5a Supported
	social cues presentation → positive emotion	0.21	0.051	3.414	<0.001***	H5b Supported

community incentives →identity construction	0.258	0.051	4.375	<0.001***	H6a Supported
community incentives →positive emotion	0.095	0.053	1.608	0.108	H6b Not Supported
social norms →identity construction	0.183	0.042	3.105	0.002**	H7a Supported
social norms →positive emotion	0.112	0.044	1.891	0.059	H7b Not Supported

Note: \*\*\*p<0.001; \*\*p<0.01; \*p<0.05.

## DISCUSSION AND IMPLICATIONS

### Summary of findings

The emergence of many Vlog communities makes a user more challenging to stay on a specific platform. Platforms that reliably gain consumers' attention stand to make significant financial gains. Involving users to contribute to the community has long been an excellent strategy to prevent switching behavior (Ma & Agarwal, 2007). The previous research of Vlog creative behavior focuses primarily on influencers (Coates et al., 2020; Lewis, 2020). However, a huge body of Vloggers is common consumers facing cold start in the early stage of video creation. Motivating them to start and insist on creation becomes essential for platforms. As such, the present study seeks to advance our understanding of beginning vloggers' creative behavior by proposing and testing a model that explores the impact of extrinsic motivation and intrinsic motivation on Vlog creative behavior mediated by two critical cognition and affection factors. Through the lens of social cognitive theory and self-discrepancy theory, we identified two extrinsic motivations (social norms and community incentives) and two intrinsic motivations (social cues presentation and social interaction) in the first stage of the model. We concluded a new construction as a mediator, identity construction, usually considered a consequence, not an antecedent of creative behavior (Cheng & Guo, 2015). The analysis of 342 questionnaire surveys shows that intrinsic motivation (social interaction and social cues presentation) positively affects identity construction and positive emotions, and identity construction and positive emotions further significantly affect the creative behavior of Vlog. Contrary to our expectations, extrinsic motivation (community incentives and social norms) only positively affects identity construction and does not significantly influence positive emotions. The explanation may be that vloggers pay more attention to expression management when stimulated by external factors, while their emotions are less affected by the external environment.

### Theoretical implications

The current research makes important theoretical contributions to the existing literature of UGC. First, to our knowledge, this is the first study to focus exclusively on beginning vloggers' creative behavior in Vlog community contexts. Second, according to self-discrepancy theory, we concluded a new construction as a mediator, identity construction. Previous studies usually considered identity construction as a consequence, not an antecedent of creative behavior (Cheng & Guo, 2015). Finally, we enhance the existing literature on vlogger engagement by applying social cognitive theory to our model.

### Managerial implications

First, the developers and managers of the Vlog community can enrich social function. To facilitate users' social interactions with beginning vloggers, short video platforms can redesign recommendation systems to increase the exposure rate and hits of beginning vloggers by accurate and customizing recommendations. Besides, more presentation of social cues is conducive to identity construction and the generation of positive emotion. The platform can design more functions to display user information. For example, vloggers can add tags in Vlog creation to disclose more comprehensive and abundant information and. Meanwhile, platforms can offer virtual rewards that show identities, such as badges, specific titles, and others that highlight the user identity of the Vlog community, and offer generous material rewards to call for high-quality Vlogs. Finally, the platform can provide users with rewards to encourage the user to share Vlogs with their friends so as to attract more potential users to create Vlogs.

### Limitations and future research

First, in the research on the factors affecting the creative behavior of Vlog, the sample selection is concentrated. The age of more than half of the population is concentrated in the 18-25 years old, and the education background is mostly junior college or undergraduate, which may cause bias in the data results. In the future, the scope of the questionnaire can be expanded, and demographic information will be more comprehensive.

Second, this research focuses on the construction of identity as an important factor in personal cognition, which also confirms the important role of internal and external factors on creative behavior. But for individuals, there are other factors that affect their cognition. In the future, other intermediary factors at the cognitive level, such as satisfaction and trust, can be added to further explore its influence mechanism.

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## **Herding Behavior in Online Restaurant Ratings: Moderating Effects of Reviewer Popularity and Observed Review Volume**

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### **ABSTRACT**

Understanding the generation of online reviews is fundamental work for retailers to better utilize them. Review rating is the most important component of an online review; therefore, our study tries to investigate the antecedents of online reviews by figuring out the relationship between a reviewer's observed review rating and his/her rating. More specifically, this study aims to answer the following three research questions: (1) Does herding behavior exist in online ratings, i.e., is a reviewer's rating affected by his/her observed ratings given by other reviewers? (2) Does the observed review number moderate the direct effect of observed review ratings on a reviewer's rating behavior? (3) Does a reviewer's popularity moderate the direct effect of observed review ratings on his/her rating behavior? To answer these research questions, we conduct multiple empirical analyses using online restaurant reviews obtained from the most popular review platform in China. The results show that herding behavior does exist in online rating behavior. To be more specific, a reviewer's observed review rating while authoring reviews are positively related to his/her review rating; The observed review volume of the rated restaurant can mitigate the positive relationship between a reviewer's observed review rating and his/her rating. A reviewer's popularity can also mitigate the positive relationship between his/her observed review rating and his/her own rating. Our study makes contributions to both academic literature and managerial practice by demonstrating the presence of herding behavior in online review ratings. Our findings offer important implications for online review platform managers, product retailers, and consumers.

*Keywords:* User-generated content, online reviews, online rating behavior, herding behavior, moderating effects.

### **INTRODUCTION**

The fast development of Web 2.0 and social media in the last decade has offered fertile ground for the emergence and accumulation of user-generated content (UGC). Among different types of UGC, online reviews are the most important form and are widely utilized by both consumers and retailers. For consumers, online reviews are treated as a trustworthy channel to obtain product information (Goh, Heng, & Lin, 2013). For retailers, it is a good way to know consumers' assessment and potential needs for the product or service (Zhou et al., 2018). Therefore, many businesses utilize online reviews as a new marketing strategy (Chen & Xie, 2008). Because of the widely recognized value of online reviews, both e-commerce researchers and practitioners pay increasingly more attention to this field.

Based on this background, understanding the generation of online reviews has become an essential task for practitioners to better utilize online reviews. To enrich studies on this topic, we will focus on the herding behavior in online review ratings. More specifically, this study aims to investigate the following three research questions: (1) Does herding behavior exist in online ratings, i.e., is a reviewer's rating affected by his/her observed ratings given by other reviewers? (2) Does the observed review number moderate the direct effect of observed review ratings on a reviewer's rating behavior? (3) Does a reviewer's popularity moderate the direct effect of observed review ratings on his/her rating behavior? To answer these research questions, we conducted several empirical analyses using online restaurant reviews collected from *PublicComments*, which is the most representative restaurant review platform in China.

We first establish the herding behavior effect using ordered logit regression. After identifying the herding behavior effect, we extend the model to check whether observed review volume and reviewer popularity on the platform can influence this effect. In addition to the main analysis, we conduct a series of robustness checks to confirm the generalizability of the results.

Our study yields the following findings. First, herding behavior does exist in online rating behavior. To be more specific, a reviewer's observed review rating while providing a review for a restaurant is positively related to his/her own rating for the restaurant. Second, the observed review volume of a restaurant can mitigate the positive relationship between a reviewer's observed review rating of the restaurant and his/her rating. Third, a reviewer's popularity can mitigate the positive relationship between his/her observed review rating of a restaurant and his/her own rating for the restaurant as well.

The remaining of this paper is structured as follows. We review related literature on consumers' online rating behavior and clarify herding behavior in the information systems (IS) domain, and then develop our hypotheses in Section 2. We describe our methodology, including data collection, variable measurement, and empirical model in Section 3. Then our result analyses are

reported in the following section. In the final section, we conclude this paper by discussing the main findings, implications, and limitations of our study.

## THEORETICAL BACKGROUND AND HYPOTHESES

### Theoretical Background

#### *Online rating behavior*

To better utilize online reviews, it is essential for both practitioners and researchers to understand the generation of online reviews (Gao, Li, Liu, & Fang, 2018). Usually, an online review includes two components: an open-ended review text comment and a five-scale star rating (Mudambi & Schuff, 2010). Between the two components, star ratings are treated more important; therefore, most existing studies on online review generation mainly focus on consumers' online rating behavior (Gao et al., 2018; Ho, Wu, & Tan, 2017; Li, 2016; Zhang, Zhang, & Yang, 2016). To be more specific, Gao et al. (2018) study the influence of reviewers' power distance on reviewers' online rating behavior and obtain a negative relationship between them. Zhang et al. (2016) identify the relationship between expert reviews and travelers' rating behavior. Moe and Trusov (2011) confirm the social influence or herding behavior in online ratings, i.e., consumers' ratings can be influenced by previous ratings. Social influence can be further divided into friends' influence and non-friends influence. Lee, Hosanagar, and Tan (2015) investigate the different impacts of friends' and non-friends social influence on reviewers' ratings and find user ratings always herd with friends' ratings but differentiate from non-friends ratings for niche movies. Wang, Zhang, and Hann (2018) empirically examine online friends' social influence bias in online book ratings by finding a significantly higher rating similarity after reviewers becoming online friends. Building on this stream of research, our study investigates herding behavior in online ratings in depth.

#### *Herding behavior*

Herding behavior refers to the phenomenon that "everyone does what everyone else is doing, even when their private information suggests doing something quite different" (Banerjee, 1992). Herding is likely to occur when individuals do not have to compete for information or face uncertain situations (Walden & Browne, 2009). Prior studies have confirmed the presence of herding behavior in a wide range of situations, such as imitating other investors' behavior while investing (Hirshleifer, Subrahmanyam, & Titman, 1994), downloading software products (Duan, Gu, & Whinston, 2009), or adopting new information systems (Sun, 2013) following others. In the context of online review generation, some reviewers are uncertain about the quality of the reviewed product or service, and these reviewers are easy to be influenced by existing reviews. Therefore, herding behavior occurs in writing online reviews.

### Hypotheses Development

#### *Herding behavior in online review ratings*

On a review platform, it is common to show the average rating of existing ratings, which we call an observed rating in this study. A reviewer knows the overall assessment of the product from this information cue, and this may cause the effects of social influence (Sridhar & Srinivasan, 2012), especially for reviewers who are uncertain about his/her own assessment. We believe a reviewer will be influenced by existing ratings and is prone to follow others' ratings while providing online ratings. Hence, we put forward the first hypothesis:

*H1: When a reviewer provides an online review for a restaurant, the rating given by him/her is positively related to the observed average rating of the restaurant.*

#### *Moderating effect of observed review volume*

Typically, a review platform also shows the information of how many reviews have been given to the product or service. This information cue may influence consumers' rating behavior. According to the attention-grabbing theory, in order to attract attention from review readers, online reviewers are prone to differentiate from the average rating if the observed review volume for the rated product is large (Shen, Hu, & Ulmer, 2015). Therefore, we argue that the observed review volume for the rated product can mitigate the herding behavior in online ratings and put forward the following hypothesis:

*H2: The observed review volume of a restaurant weakens the relationship between the reviewer's observed average rating of the restaurant and the rating given by him/her.*

#### *Moderating effect of reviewer popularity*

Most review websites allow users to interact with each other by following others. Reviewers with more fans or followers usually have more experience and know-how to behave smartly to attract more attention and fans. Negative reviews are treated more helpful by readers, so negative reviews will attract more users' attention. As reviewers become more popular, their numerical review ratings become more negative (Goes, Lin, & Au Yeung, 2014). For reviewers with low popularity, they may not know the way to act smartly to obtain more followers, or they do not want to, so they are less likely to provide lower ratings and more likely to be influenced by existing ratings; while for those with more fans, they are more experienced to know how to attract more followers. Hence they tend to provide lower ratings and less be likely to be impacted by existing ratings. Therefore, we put forward the following hypothesis:

*H3: The popularity of a reviewer weakens the relationship between his/her observed average rating of a restaurant and the rating given by him/her to the restaurant.*

Our research model is illustrated in Figure 1 below.

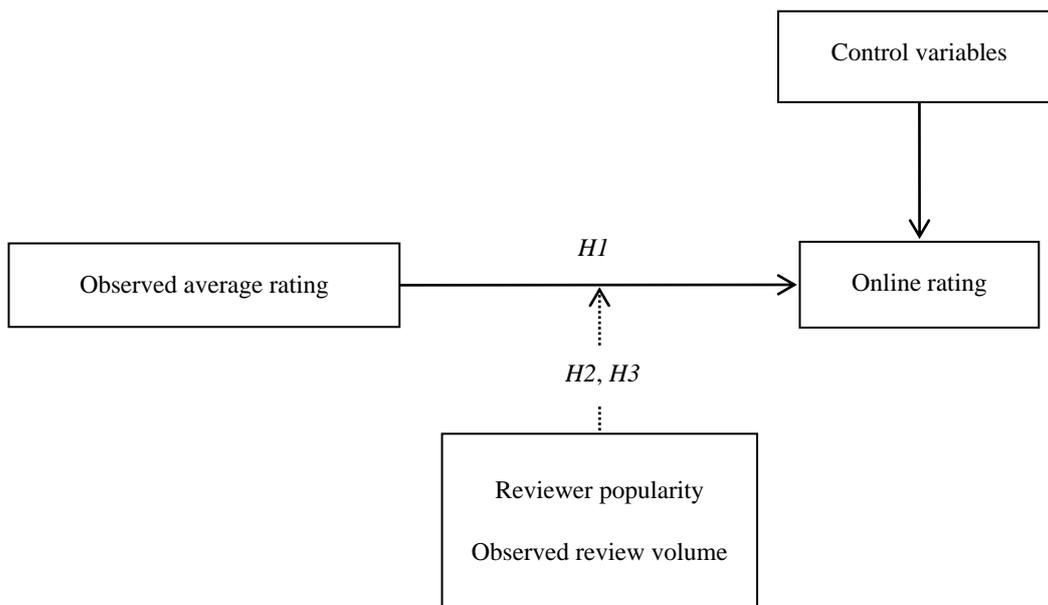


Figure 1: Research model.

## METHODOLOGY

### Data

The main data source of this study is the most popular reputation platform in China, which we designate an alias as *PublicComments* for anonymity purposes. We first developed a web crawler and collected data of reviews for a set of restaurants from it, spanning the period between 2004 and 2017. For the restaurant sample, we randomly selected ten major cities in China (Amoy, Changsha, Chengtu, Dalny, Harbin, Kunming, Sanya, Tsingtao, Xi'an, and Xining). In this study, we just collected review data for ten restaurants with the largest numbers of online reviews for each city in order to improve the efficiency of data collection. Every consumer review for a restaurant since the restaurant is added to the platform was collected. Each review contains a timestamp and review content (an overall rating, three sub-ratings, text, and pictures, etc.) in addition to the reviewer- and restaurant-related information. After dropping the observations with missing data, 87,895 reviews were included in our main analysis, while 92,106 in the robustness check.

### Variables and Measures

#### Dependent variable

Following prior research (Gao et al., 2018; Ho et al., 2017; Li, 2016; Zhang et al., 2016), we adopt review rating as the dependent variable. It is an integer and ranges from 1 to 5 based on the five-star rating scale of *PublicComments*. More stars indicate more positivity, and one star represents the worst evaluation for a product or service. In general, the review rating given by a consumer can be used to indicate his/her satisfaction with the product or service (Gu & Ye, 2014).

#### Independent variable

When a reviewer provides a review for a restaurant where s/he had dinner, the average rating aggregated from pre-existing reviews of the restaurant can be explicitly observed by him/her. In this study, we use it as the independent variable and name it *obsAvgRating*.

#### Moderating variables

The variables of *reviewerPopularity* (measured by the number of fans owned by a reviewer on the platform) and *obsReviewVolume* (measured by the number of pre-existing reviews of a restaurant observed by a reviewer when s/he provides a review for the restaurant) are treated as moderator variables in our study.

#### Control Variables

To robustly test our research hypotheses, we also include a comprehensive set of control variables in addition to the key variables mentioned above. The variable of *consumPerPerson* is measured by the per capita cost disclosed by the reviewer in a review. The variable of *travelReview* is a binary variable, and it is equal to zero if the city of residence disclosed in the reviewer's profile and the city where the restaurant is located the same and 1 otherwise. The variable of *vipReviewer* is also a binary variable to indicate whether the reviewer has been approved to be a VIP user by the platform. The variable of *reviewerEconStatus* is measured by the average annual GDP per capita from 2005 to 2015 of the reviewer's residence city to reflect his/her regional economic status. The economic data can be obtained from the CEIC database (<https://insights.ceicdata.com/>). The variable of *reviewerActivity* is measured by the ratio of the number of restaurants reviews

the reviewer has posted on the platform to the number of days the reviewer has experienced since s/he signed up as a registered user of the platform. Moreover, we also control for the fixed effects of restaurants (*restaurantFE*) in our analysis.

We present all the variables and their measurement in Table 1. In order to reduce skewness, natural log-transformations are adopted for the variables of *obsReviewVolume*, *consumPerPerson*, *reviewerPopularity*, and *reviewerActivity*. Besides, the GDP data are in a unit of 100,000 RMB.

Table 1: Variable description.

Variable Type	Variable	Description
Dependent variable	<i>rating</i>	The overall rating of a restaurant given by a reviewer (ordered variable with five cases: 1, 2, 3, 4, and 5).
Independent variable	<i>obsAvgRating</i>	A restaurant's average rating at the time was just before a reviewer provided the focal review.
Moderating variable	<i>reviewerPopularity</i>	The number of followers owned by a reviewer.
	<i>obsReviewVolume</i>	The number of a restaurant's reviews at the time just before a reviewer provided the focal review.
Control variable	<i>consumPerPerson</i>	The per capita cost was disclosed by the reviewer in the review.
	<i>travelReview</i>	A binary variable, which equals 0 if the city of residence disclosed by the reviewer on his/her homepage and the city where the restaurant is located the same, and 1 otherwise.
	<i>vipReviewer</i>	A binary variable indicating whether the reviewer has been recognized as a VIP user of the platform.
	<i>reviewerEconStatus</i>	It is measured by the average annual GDP per capita from 2005 to 2015 of the reviewer's residence city.
	<i>reviewerActivity</i>	They are measured by the ratio of the number of restaurant reviews the reviewer has posted to the number of days the reviewer has experienced since s/he signed up as a registered user of the platform.
	<i>restaurantFE</i>	The fixed effects of the restaurants.

### Empirical Model

Given the nature of the dependent variable, which is a discrete, ordered, and censored variable, we choose to employ an ordered logistic regression model following previous literature (Gao et al., 2018; Huang, Burtch, Hong, & Polman, 2016) to estimate the results.

## RESULTS

### Descriptive Analysis

Table 2 and Table 3 report the descriptive statistics and correlation matrix for the main variables in our study, respectively. It is worth noting that we just report the original value of *obsReviewVolume*, *consumPerPerson*, *reviewerPopularity*, and *reviewerActivity* in the descriptive statistics to better provide a more intuitive description of the data set, whereas we take a natural log conversion for these variables in the correlation analysis and the regression analyses due to their large skewness. As we can see from Table 2, the data set is representative.

Table 3 provides the correlation matrix of the main variables in our study. As we can see from the correlation matrix, all the correlations between the two variables are small and below 0.5. To further rule out the multicollinearity issue, we calculated the variance inflation factor (VIF) values for all independent variables. All the VIF values are far below 5, indicating that multicollinearity is not a threat to our study.

Table 2: Descriptive Statistics of Variables.

Variable	Obs#	Mean	Std. Dev.	Min	Max
<i>rating</i>	104,581	4.228	1.002	1	5
<i>obsAvgRating</i>		4.224	0.417	1	5
<i>reviewerPopularity</i>		44.439	147.786	0	9,467
<i>obsReviewVolume</i>		3,994.941	3,478.877	1	22,379
<i>consumPerPerson</i>		141.823	6,536.737	1	1,000,000
<i>travelReview</i>		0.624	0.484	0	1
<i>vipReviewer</i>		0.223	0.416	0	1
<i>reviewerEconStatus</i>		0.649	0.181	0.068	1.391
<i>reviewerActivity</i>		0.442	6.572	0.000	880

Table 3: Correlation Matrix and VIF Values of Main Variables.

	1	2	3	4	5	6	7	8	9	10	VIF
2	0.339										1.45
3	0.129	0.370									1.40
4	-0.120	-0.415	-0.474								1.42
5	0.050	0.230	0.082	-0.023							1.07
6	0.006	-0.045	0.081	-0.048	0.000						1.27
7	-0.072	-0.019	0.090	-0.037	-0.031	0.005					1.33
8	0.026	0.062	0.060	-0.048	0.007	0.435	0.011				1.25
9	-0.064	-0.062	0.004	0.001	-0.017	0.052	0.479	0.067			1.40
10	0.072	0.242	0.064	-0.077	0.107	-0.087	-0.137	-0.036	-0.274		1.16
11	-0.104	-0.219	-0.180	0.121	-0.096	-0.077	0.179	-0.070	0.182	-0.139	1.13

Notes: 1: *rating*; 2: *obsAvgRating*; 3: *obsReviewVolume*; 4: *obsAvgRating* × *obsReviewVolume*; 5: *consumPerPerson*; 6: *travelReview*; 7: *vipReviewer*; 8: *reviewerEconStatus*; 9: *reviewerPopularity*; 10: *obsAvgRating* × *reviewerPopularity*; 11: *reviewerActivity*.

### Main Analysis

Following the common practice, in order to avoid nonessential multicollinearity between a variable and its corresponding interaction term(s), the moderating variables (i.e., *obsReviewVolume* and *reviewerPopularity*) and the independent variable (i.e., *obsAvgRating*) were centered by subtracting their respective mean values to obtain the interaction term of a moderating variable and the independent variable in the regression analyses (Cohen, Cohen, West, & Aiken, 2003). We report the estimation results of our main analysis in Table 4.

After taking the effects of all control variables into account, we can find that a significantly positive relationship does exist between the dependent variable and the independent variable ( $b=0.761^{***}$ ). This result supports the hypothesis of *H1*, indicating that the higher the observed average rating of a restaurant, the higher an online rating will be given by the focal reviewer to the restaurant.

The interaction terms are also significant, implying that the marginal effect of observed average rating on online rating depends on the reviewer’s popularity and his/her observed review volume of the restaurant. Specifically, the positive influence of the observed average rating on the focal rating is weaker for reviewers with more followers or restaurants with more existing reviews. As such, both of the other two hypotheses, *H2* and *H3*, are also supported.

Table 4: Main Results.

	Model 1	Model 2	Model 3
<i>obsAvgRating</i>		<b>0.761***</b> <b>(0.035)</b>	<b>0.680***</b> <b>(0.041)</b>
<i>obsReviewVolume</i>	0.272*** (0.006)	0.175*** (0.007)	0.167*** (0.007)
<i>obsAvgRating</i> × <i>obsReviewVolume</i>			<b>-0.082***</b> <b>(0.015)</b>
<i>consumPerPerson</i>	-0.347*** (0.018)	-0.338*** (0.018)	-0.335*** (0.018)
<i>travelReview</i>	0.164*** (0.020)	0.167*** (0.020)	0.156*** (0.020)
<i>vipReviewer</i>	-0.402*** (0.017)	-0.398*** (0.017)	-0.398*** (0.016)
<i>reviewerEconStatus</i>	-0.146** (0.048)	-0.156** (0.049)	-0.153** (0.049)
<i>reviewerPopularity</i>	-0.025*** (0.005)	-0.025*** (0.005)	-0.045*** (0.005)
<i>obsAvgRating</i> × <i>reviewerPopularity</i>			<b>-0.115***</b> <b>(0.009)</b>
<i>reviewerActivity</i>	-0.109*** (0.017)	-0.100*** (0.017)	-0.106*** (0.017)
<i>restaurantFE</i>	Yes	Yes	Yes
Constant Cut 1	-3.312*** (0.116)	-0.756*** (0.166)	-1.247*** (0.200)
Constant Cut 2	-2.441*** (0.115)	0.116 (0.165)	-0.374 (0.200)
Constant Cut 3	-1.024*** (0.115)	1.537*** (0.165)	1.048*** (0.200)

Constant Cut 4	0.599*** (0.115)	3.167*** (0.166)	2.681*** (0.200)
Observations	87,913	87,895	87,895

Notes: Cut *i* is the cut-point corresponding to the ordered category of online ratings; robust standard errors are included in parentheses; \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ .

**Robustness Checks**

We investigate the robustness of our results in two different ways: (1) Utilizing alternative measurement for key variables; and (2) utilizing alternative estimation method.

**Robustness check with alternative measurement**

We verify the robustness of our results with alternative measurements for the dependent and independent variables. As mentioned earlier, besides an overall rating for the restaurant in a review, users can also provide a rating on three sub-dimensions (taste of the food, restaurant environment, and service quality). In order to utilize the trait of such a multi-dimensional rating system, we converted the measurement of the dependent variable from the overall rating to the three sub-ratings and that of the independent variable from the observed average overall rating to the observed average sub-ratings to re-conduct corresponding analyses. Table 5 presents the results estimated with the three alternative, dependent variables, and corresponding independent variables. The results are remarkably consistent with the results from the main analysis, demonstrating the solid robustness of our research findings.

Table 5: Results of Robustness Check-in Sub-rating Dimensions.

	DV: <i>tasteRating</i>	DV: <i>environmentRating</i>	DV: <i>serviceRating</i>
<i>obsAvgRating</i>	<b>0.503***</b> (0.016)	<b>0.586***</b> (0.014)	<b>0.556***</b> (0.012)
<i>obsReviewVolume</i>	0.090*** (0.008)	0.053*** (0.007)	0.057*** (0.008)
<i>obsAvgRating</i> × <i>obsReviewVolume</i>	<b>-0.034***</b> (0.004)	<b>-0.053***</b> (0.003)	<b>-0.039***</b> (0.003)
<i>consumPerPerson</i>	-0.233*** (0.017)	-0.250*** (0.018)	-0.237*** (0.017)
<i>travelReview</i>	0.143*** (0.019)	0.136*** (0.019)	0.153*** (0.019)
<i>vipReviewer</i>	-0.392*** (0.016)	-0.354*** (0.016)	-0.318*** (0.016)
<i>reviewerEconStatus</i>	-0.107* (0.047)	-0.253*** (0.047)	-0.169*** (0.047)
<i>reviewerPopularity</i>	-0.046*** (0.005)	-0.052*** (0.005)	-0.061*** (0.005)
<i>obsAvgRating</i> × <i>reviewerPopularity</i>	<b>-0.029***</b> (0.003)	<b>-0.019***</b> (0.002)	<b>-0.024***</b> (0.002)
<i>reviewerActivity</i>	-0.038** (0.015)	-0.069*** (0.015)	-0.083*** (0.014)
<i>restaurantFE</i>	Yes	Yes	Yes
Constant Cut 1	-0.881*** (0.153)	-1.410*** (0.147)	-0.910*** (0.135)
Constant Cut 2	0.782*** (0.152)	0.867*** (0.146)	0.879*** (0.134)
Constant Cut 3	2.123*** (0.152)	2.298*** (0.147)	2.172*** (0.135)
Constant Cut 4	3.606*** (0.153)	3.812*** (0.147)	3.521*** (0.135)
Observations	92,085	91,005	92,106

Notes: Cut *i* is the cut-point corresponding to the ordered category of online ratings; robust standard errors are included in parentheses; \*:  $p < 0.05$ , \*\*:  $p < 0.01$ , \*\*\*:  $p < 0.001$ .

**Robustness check with an alternative method**

To further investigate the robustness of the results from another angle, we conducted linear regression analyses with ordinary least squares (OLS) estimates in the overall rating dimension and three sub-rating dimensions. The corresponding results are displayed in Table 6. As we can see, the relationships between the focal variable as well as other control variables and the dependent variable still hold in all the four rating dimensions.

Table 6. Results of Robustness Check with OLS Estimates.

	DV: <i>rating</i>	DV: <i>tasteRating</i>	DV: <i>environmentRating</i>	DV: <i>serviceRating</i>
<i>obsAvgRating</i>	<b>0.275***</b> (0.021)	<b>0.228***</b> (0.008)	<b>0.281***</b> (0.007)	<b>0.287***</b> (0.007)
<i>obsReviewVolume</i>	0.068*** (0.003)	0.039*** (0.004)	0.016*** (0.003)	0.023*** (0.004)
<i>obsAvgRating</i> × <i>obsReviewVolume</i>	<b>-0.064***</b> (0.009)	<b>-0.029***</b> (0.002)	<b>-0.035***</b> (0.001)	<b>-0.032***</b> (0.001)
<i>consumPerPerson</i>	-0.179*** (0.009)	-0.130*** (0.009)	-0.127*** (0.008)	-0.129*** (0.009)
<i>travelReview</i>	0.051*** (0.009)	0.053*** (0.009)	0.047*** (0.008)	0.059*** (0.009)
<i>vipReviewer</i>	-0.121*** (0.008)	-0.142*** (0.008)	-0.126*** (0.008)	-0.118*** (0.008)
<i>reviewerEconStatus</i>	-0.082*** (0.022)	-0.054* (0.022)	-0.118*** (0.021)	-0.087*** (0.023)
<i>reviewerPopularity</i>	-0.008*** (0.002)	-0.011*** (0.002)	-0.015*** (0.002)	-0.020*** (0.002)
<i>obsAvgRating</i> × <i>reviewerPopularity</i>	<b>-0.039***</b> (0.005)	<b>-0.008***</b> (0.001)	<b>-0.005***</b> (0.001)	<b>-0.007***</b> (0.001)
<i>reviewerActivity</i>	-0.035*** (0.009)	-0.011 (0.009)	-0.036*** (0.008)	-0.042*** (0.008)
<i>restaurantFE</i>	Yes	Yes	Yes	Yes
Constant	3.369*** (0.099)	1.711*** (0.079)	1.525*** (0.070)	1.472*** (0.071)
Observations	87,895	92,085	91,005	92,106
R-squared	0.149	0.214	0.356	0.323

Notes: Cut  $i$  is the cut-point corresponding to the ordered category of online ratings; robust standard errors are included in parentheses; \*,  $p < 0.05$ , \*\*\*,  $p < 0.001$ .

## CONCLUSION AND DISCUSSIONS

### Main Findings

The main purpose of this study is to confirm the herding behavior in online ratings and figure out the moderating effects of product and reviewer characteristics. *PublicComments*, which is the most popular restaurant review platform, provides us with an appropriate context to answer the above-mentioned research questions. We first test the herding behavior effect using ordered logit regression. After confirming the presence of herding behavior, we apply another regression to check whether observed restaurant review volume and reviewer popularity influence this effect, and then we conduct robustness checks using alternative measurement for the dependent and independent variables and an alternative estimation method. The results of the hypotheses testing are reported in Table 7.

Our results show that herding behavior does exist in online rating behavior. To be more specific, a reviewer's observed review rating while authoring reviews is positively related to his/her review rating. The observed review volume of a restaurant can mitigate the positive relationship between a reviewer's observed review rating of the restaurant and his/her rating; a reviewer's popularity can also mitigate the positive relationship between the reviewer's observed review rating and his/her rating.

Table 7: Summary of Hypotheses Testing.

Hypothesis	Result
H1: When a reviewer provides an online review for a restaurant, the rating given by him/her is positively related to the observed average rating of the restaurant.	Supported
H2: The observed review volume of a restaurant weakens the relationship between the reviewer's observed average rating of the restaurant and the rating given by him/her.	Supported
H3: The popularity of a reviewer weakens the relationship between his/her observed average rating of a restaurant and the rating given by him/her to the restaurant.	Supported

### Implications

Our study has both theoretical and practical implications. From the theoretical perspective, this study enriches research on online review generation. Given that understanding online review generation is a fundamental process for retailers to take advantage of online reviews, it is essential to identify factors influencing the generation of online reviews, especially online ratings. We confirm the herding behavior in online restaurant ratings and make some attempts to find out the mechanism behind it.

From the practical angle, our research findings are helpful for review platform managers to design better review rating systems and useful for consumers to understand online ratings better. Our study suggests that reviewers tend to provide higher ratings for restaurants with higher observed ratings, especially for restaurants with fewer reviews and reviewers with fewer fans. Therefore, it is advisable for platform managers to show average ratings differently for products with different popularity. To avoid reviewers being influenced by existing ratings, maybe the platform should avoid showing the review volume for niche products.

### Limitations and Future Work

This study has some inherent limitations. First, we adopt a simple sampling method in this study. More specifically, to improve the efficiency of data collection, we just included ten restaurants in 10 randomly selected cities, which may impact the generalizability of this study. Future research should include more restaurants in studies, especially those with relatively less popularity. Second, we just test our research hypotheses in the catering business context, and we can further test the online reviewers' herding behavior in other contexts, such as the hotel industry, to achieve better generalizability. Third, besides the popularity levels of restaurants or reviewers, there are many other factors influencing online reviewers' herding behavior. Therefore, it is essential to investigate more mechanisms behind reviewers' herding behavior in future work.

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## How Do Consumers Identify Useful Review Information in a Social Media Environment?

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### ABSTRACT

The popularity of social network services (SNS) provides consumers with new channels to obtain information, and the convenience and diversity of information help consumers reduce the uncertainty and risk in online shopping. However, with the development of the internet, increasing information is available to consumers, and the information overload of online reviews (ORs) creates higher requirements for consumer information screening. Therefore, how to quickly and accurately identify useful information becomes important. There is much literature discussing the usefulness of online word of mouth and ORs, but these studies generally explore information selection and judgment in the traditional business to consumer environment and do not specifically explore social shopping in SNS. In addition, the existing results often only consider the quality factor of ORs and ignore the influence of consumers' personal choice preferences and the characteristics of OR publishers on consumer behavior. From this, based on the theory of planned behavior and the online trust model, this paper determines the relevant factors and frameworks that affect the usefulness of ORs in the SNS environment. We start from the perspectives of reviewer-related and information-related aspects. Partial least squares structural equation modeling (PLS-SEM) was used to analyze 237 samples for eight factors: credibility, social distance, evaluation (positive and negative), information quality (accuracy, timeliness, and integrity), and presentation. This study enriches the theory of OR usefulness in the SNS environment and provides a reference for the online marketing of enterprises.

*Keywords:* Online reviews, social network services, consumer behavior, online trust.

### INTRODUCTION

According to the 48<sup>th</sup> Statistical Report on The Development of Communication in China released by the China Internet Network Information Center, by June 2021, the number of mobile phone netizens in China had reached 1.007 billion, and the number of users of online videos (including short videos) in China had reached 944 million. All major social media are favored and widely used by netizens to varying degrees. The number of online shoppers in China has reached 812 million, accounting for 80.3% of the total number of internet users.

With the development of information and communication technology, social network services (SNS) have undergone tremendous changes. Taking the tourism industry as an example, consumers can rely on the internet to conveniently choose different services and spread information related to travel services through social media (Navío-Marco et al., 2018). The rise of major social platforms has substantially increased the reach of SNS. Online platforms also provide convenience for consumers to exchange relevant service information. Consumers can search online and make decisions based on the electronic word of mouth of existing customers (Khawaja et al., 2020). The development of SNS has increased the importance of online reviews (ORs) while providing consumers with an avenue for sharing consumer experiences. Nowadays, numerous e-commerce platforms have added online comment features. As a new communication method of word of mouth, ORs' scope and depth of influence have multiplied. However, many ORs are published in the online shopping environment, and consumers cannot process this large amount of information. For consumers, this may cause information overload, increase cognitive costs, and reduce their decision-making efficiency. A large amount of information poses a challenge to consumers' information screening. Information overload brings difficulties to consumers in decision-making and choosing. Consumers are faced with the need to identify useful ORs (Liu et al., 2021). This paper addresses the following question:

*What factors affect the usefulness of ORs in the SNS environment?*

In this study, ORs in SNS were defined as consumers' opinions on companies, products, and shopping experiences posted on social media such as forums, social networks, blogs, Weibo, and instant-messaging tools. To explore the factors that influence consumers in the process of identifying useful ORs in the SNS environment, we applied the theory of planned behavior (TPB) and the online trust model proposed by Cao and Yan (2014). Examining two perspectives—that of the information published

and that of the review information—and considering the credibility of the reviewer, the social distance between the reviewer and the reader, the quality of the review information, presentation type, and the consumer's emotional tendency toward the review information. In this paper, 237 valid samples obtained by random sampling are analyzed with the help of a partial least squares structural equation model (PLS-SEM). The results reveal the factors that affect consumers' perception of the usefulness of SNS ORs. We compare different factors to identify their relative impacts on the usefulness of SNS ORs and propose an operating mechanism for consumers to identify and judge the usefulness of ORs. The research results expand the research on ORs in the SNS environment and can help practitioners formulate more effective online marketing strategies.

The structure of this paper is as follows. First, relevant literature pertaining to ORs, SNS, and information usefulness is summarized. Then, based on TPB and the online trust model, we propose a research framework for analyzing OR usefulness and corresponding hypotheses. Furthermore, this study designed a questionnaire based on existing literature to collect data of different influencing factors to test the usefulness of ORs. Then, with a sample size of 237 respondents, a PLS-SEM was used to test the hypotheses. Finally, we present the conclusions, their theoretical and practical significance, limitations of this study, and suggestions for future research.

## LITERATURE REVIEW

In 1998, the first successful online transaction marked the formal transformation of Chinese e-commerce from the concept to the initial application stage. The following year, the internet book spawned the development of the business-to-consumer model. Although the online shopping industry was negatively impacted by the National Association of Securities Dealers Automated Quotations at the beginning of 2000, the SARS epidemic in 2003 made more and more people aware of the convenience of online shopping and its market situation gradually improved. Since then, many online shopping websites, such as Taobao, Jingdong, eBay, and Paipai, have been successfully launched, and China's e-commerce has entered a prosperous era. The COVID-19 epidemic has left people in isolation for a long time, and online shopping has successfully evolved to become an indispensable part of people's lives. According to the Statistical Report on the Development of China Internet released in August 2021, online retail, as a new consumption engine, amount to 6.11 trillion yuan in industry size in the first half of 2021. From the perspective of absolute value, this data is considerable, but its increase has been only 23.2% from the same period last year, indicating a slowdown. To improve the situation for online shopping and help it regain vitality, more and more scholars believe that the answer starts with ORs, which are one of the important sources of product information and impact on consumers' online shopping decisions (Vithayathil et al., 2020; Wu & Liao, 2021).

Consumers increasingly use ORs as a reference for their purchase decisions because there are conflicts of interest between e-commerce operators and consumers (Camilleri, 2021). Online reviews based on platforms of third-party agents (TPAs) and service providers are susceptible to manipulation (Moore & Lafreniere, 2020). In contrast, ORs in the SNS environment can better reflect the nature of the product and reduce the risk of online shopping caused by unequal information between buyers and sellers (Du et al., 2019). Second, with the popularity of SNS, the cost for consumers to search for information has decreased, and the efficiency of obtaining information is constantly rising (Liu & Park, 2015). Studies have shown that product categories, quality of online reviews, and reviewer characteristics directly influence consumer perception of ORs and indirectly influence their willingness to buy (Liu & Ji, 2018; Malik & Hussain, 2020). More empirical analysis has found positive and negative emotions as the most influential affective dimensions (Malik & Hussain, 2017), and even the joy or sadness revealed in the literal expression of the comments has a notable impact on consumers' perception of the utility of ORs (Wu & Liao, 2021). ORs are useful in the SNS environment, but there are high cognitive costs associated with the attributes of reviewers (Liu & Park, 2015): Is the information expressed in comments real and objective? How to judge its validity? Regarding such issues, Vithayathil et al. (2020) proposed that online reviews are comprehensively influenced by multiple dimensions (social and emotional dimensions and personal concerns) based on 9,622 consumer reviews of hearing care services. Zhang et al. (2021) proposed a method based on fine-grained emotion analysis and the Kano model, which extracts consumer demand for product attributes from online reviews. The author concluded that there is a significant positive correlation between product sales and the extracted attractiveness and one-dimensional product attributes. Malik and Hussain (2017) examined different negative styles in electronic word of mouth and found that consumers are more responsive to product evaluation when reviews contain agreed negation.

The existing results suggest that ORs have become an important source for consumers to obtain evaluation information on related goods and services and are one of the important means for consumers to control risk (Banerjee et al., 2017). Consumers tend to use ORs to reduce the uncertainty faced in an e-commerce environment (Naujoks & Benkenstein, 2020). Studies have shown that ORs have significant effects on consumers' truest intent and willingness to buy (Park et al., 2021). However, previous studies have focused on the impact of information quality on information usefulness and rarely comprehensively discussed the common impact of information reviewers, information quality, and choice preferences of comment readers during the process of identifying the usefulness of the information. Furthermore, specific mechanisms by which consumers identify useful information from SNS have not been identified. Therefore, this study tries to understand the degrees to which various factors affect the usefulness of ORs in the SNS environment from the three perspectives of information reviewers, readers, and comment information.

## THEORETICAL FOUNDATION AND HYPOTHESES DEVELOPMENT

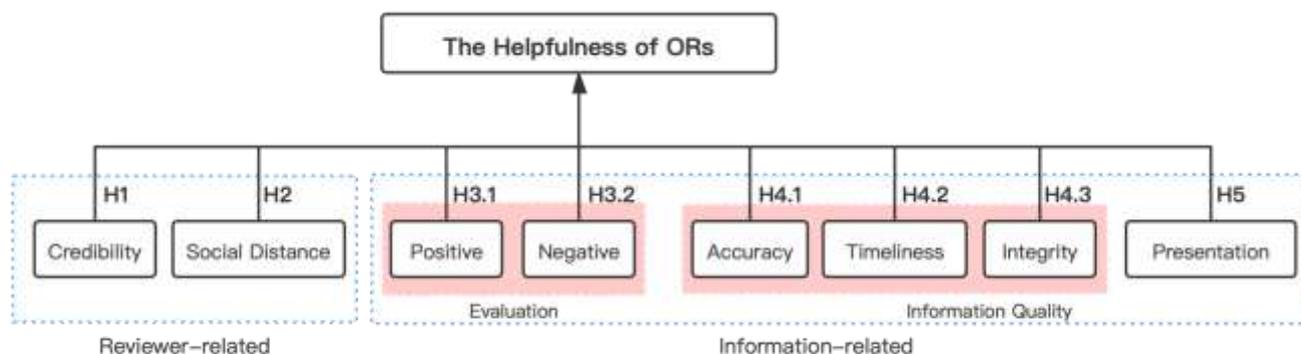
### Theoretical Foundation

Many factors influence behavior indirectly through behavioral intent, which in turn is influenced by three related factors: one is the individual's attitude, that is, the degree of preference for some behavior; the second is subjective norms, that is, the social pressure felt for performing some behavior; and the third is perceptual, behavioral control, which reflects the individual's experience and expectations (Ajzen, 1991). When consumers consider conducting an activity, behavioral intention is the most appropriate way to evaluate whether they act and how they act. In addition, the trust framework suggests that personal consumer attitudes, ORs, and TPAs are the three main factors affecting behavioral intent in an online environment. When consumers show more positive emotions, ORs contain more positive comments on the product, and TPAs express a more supportive attitude, the greater the consumer trust tendency, and vice versa.

According to the combination of TPB and the trust framework model proposed by Cao and Yan (2014), ORs in the SNS environment is an important influencing factor for consumers engaging in online shopping. ORs affect consumer behavior and decisions through three aspects: publishers, readers, and their characteristics. ORs are influenced through the credibility of the reviewer and the relationship between the reviewer and the reader, and their characteristics indicate their accuracy, integrity, timeliness, expression, and positive/negative comment information that the reader senses from the ORs.

**Research Framework and Hypothesis**

Generally speaking, ORs in SNS do not exist independently in the online shopping environment. They have two distinct aspects: reviewer-related and information-related. Given these two sides, this study argues that the factors determining the usefulness of ORs in the SNS environment are divided into two main categories: the information quality perceived by the reviewers and the consumers. Specifically, reviewers' factors include their own credibility and the strength or weakness of their relationship with information recipients, and consumers' perception of information quality is influenced by both the impact of positive/negative comment information on consumers and the quality of the information itself, as shown in **Figure 1**.



Source: This study.

Figure 1: Theoretical research framework.

Despite a large number of literature reviews on the usefulness of comments, few have considered the characteristics of reviewers alongside the quality of the information in the context of SNS. According to the theory of emotional coherence, the personal characteristics of information reviewers will have positive or negative effects on the effectiveness of the review information (Adaval, 2001). Plotkina and Munzel (2016) investigated the interplay between reviewers' expertise and the usefulness of review information and found that positive expert reviews seemed to improve recipients' purchase intention more effectively than peer consumer reviews, and negative consumer reviews were more likely to reduce recipients' intention than negative expert reviews. Commenters with many followers are considered key opinion leaders on a platform and have a large influence on the behavior of their followers. Stamolampros et al. (2019) were the first to explore the influence of reviewers' cultural characteristics on their online review behavior. For example, there was a positive correlation between online ratings and textual testimonials provided for travel and hotels. Bigne et al. (2021) empirical results show that reviewer expertise significantly moderates the relationship between reviewer length and reviewer reliability, and experienced reviewers provide more persuasive reviews. Therefore, in this study, we use the characteristics of raters as a model of the impact of rating characteristics on rating usefulness, under the following assumption: online ratings provided in tourism and hospitality and their textual testimonials indicate a positive correlation.

**H1.** *The credibility of commenters has a positive impact on consumers' judgment of the usefulness of ORs in SNS.*

Social distance is the degree to which individuals perceive a lack of intimacy with individuals who differ in race, race, religion, occupation, or other variables (Park et al., 2021; Park, 1924). Huang et al. (2021) and Liberman and Trope (2014) mentioned that social distance describes an individual's emotional closeness in society and reflects the similarity and familiarity between the self and others. With the continuous development of SNS, users may have different reactions and evaluations to individuals with different relationship strengths with them. Some scholars have pointed out that social distance will affect consumers' psychological belonging to social media platforms, thus affecting their participation behaviors (Kwon, 2020). Specifically,

according to the empirical research results of Huang et al. (2021), based on 315 online ride-hailing users, social distance has both direct and indirect effects on consumption intention: the greater the social distance, the lower is the cooperative consumption intention. Moreover, when the perceived social distance of consumers is small, the influence of subjective norms and perceived behavioral control on collaborative consumption intention is weakened. Social distance in different consumer groups, product categories, sales, and marketing is different between the sellers; however, the existing analyses do not consider the dynamic effects in the psychological distance, social distance, and influence of the relationship between levels. Analysis of the influence of social distance on consumer purchase intentions and mechanisms of its action is still relatively lacking. Therefore, we believe that social distance (relationship strength) between readers and reviewers should also be taken into consideration when exploring the effectiveness of online reviews. Therefore, we propose the following hypothesis.

**H2.** *Social distance (relationship strength) between reviewers and readers has a positive impact on consumers' judgment of the usefulness of ORs in SNS.*

Positive ORs are positive evaluation and recognition of product quality, packaging, experience, after-sales service, and other content. Negative ORs have negative information about some or all of these aspects. OR credibility relies on members' screening preferences for positive and negative information. Some consumers think that the emotional bias of positive reviews is more practical for their understanding of the product (Guo et al., 2020), whereas other consumers prefer to pay more attention to negative information and commit more screening and thinking about negative information (Unkelbach et al., 2020), especially high-risk aversion travelers who usually focus on negative ORs when making online purchases of travel products (Casaló et al., 2015). It is unknown if contradictory opinions are more thought-provoking and better for understanding. Readers' choice preferences for information can accurately convey relevant product information to them and increase the effectiveness of ORs in the SNS environment. Further research on the impact of consumer cognitive preferences for positive and negative evaluation on the effectiveness of OR in SNS is needed. Therefore, we propose the following hypothesis.

**H3.1.** *Positive evaluation perceived by consumers will have positive effects on their judgment of the usefulness of ORs in SNS.*

**H3.2.** *Negative evaluation perceived by consumers will have a positive effect on their judgment of the usefulness of ORs in SNS.*

Information credibility means the consumers' perception of ORs in the SNS environment. Information quality is one of the key factors affecting information credibility (Cheng et al., 2021). Accurate content, complete expression, and current and practical quality-related information can effectively improve the chances of OR adoption in SNS environments (Jiang et al., 2021), but high-quality information is generally not easily obtainable. ORs in the SNS environment is usually not objective; they contain the subjective impression of consumers due to personal bias or limitations. When commenting on a product, consumers may exaggerate their consumer experience in trying to achieve the purpose of discrediting or flattering the product (Kapoor et al., 2021). What this exaggerated subjective impression conveys—whether anger and negative emotions of fear or positive feelings of pride and surprise—indirectly affects consumer perception of the effectiveness of ORs (Chen & Farn, 2020). If consumers are induced by inaccurate comment information, it will seriously affect their online shopping experience and reduce their trust in the effectiveness of ORs in the SNS environment. Moreover, some merchants deliberately withhold negative reviews to hide the shortcomings of their products. This unethical behavior invalidates the integrity of the comment information and significantly affects consumers' judgment of the effectiveness of ORs in the SNS environment. In addition, ORs' timeliness illustrates the extent to which comment information is synchronized with product sales. Influenced by dynamic demand, consumers are not necessarily interested in what they liked a year ago. Thus, compared to reviewing past products, information that comments on the latest products per user preferences is a better reference (Yuan et al., 2019), which can enhance consumer perceptions of the effectiveness of ORs in the SNS environment. Considering the above theory and previous analysis, this article posits that the positive role of information quality on the effectiveness of ORs is worth discussing. Accuracy, integrity, and timeliness are considered as the three criteria for OR quality evaluation, thus leading to the following hypothesis.

**H4.1.** *The accuracy of comment information has a positive impact on consumers' judgment of the effectiveness of ORs in SNS.*

**H4.2.** *The integrity of the comment information has a positive impact on consumers' judgment of the effectiveness of ORs in SNS.*

**H4.3.** *The timeliness of comment information has positive effects on consumers' judgment of the effectiveness of ORs in SNS.*

Online reviews can be presented in a variety of forms, such as text, images, graphic combinations, and short videos. Manganari and Dimara (2017) argued that image content enhances the diagnostic nature of online reviews because it conveys emotion, increases vividness, and strongly resonates with both users and reviewers. Different presentation forms have different effects on the transmission of the usefulness of comment information. Nazlan et al. (2018) investigated the association between comment form (text and images) and meal intention and menu item selection. Their results showed that text comments generated higher visit intentions, and images increased the likelihood of selecting a positive review menu item. This result demonstrates that the presentation form of comment information has an impact on online comments in social networks. Filieri

et al. (2021) studied the influence of verbal and visual comment cues on consumers’ intention and behavior based on the dual coding theory and concluded that popularity heuristics, presentation visual heuristics, and user-generated images influence tourists’ willingness and decision to visit destinations and attractions. With the further development of network services, online reviews are presented in various forms. Therefore, we hypothesize the following:

**H5.** *The presentation form of comment information has a positive impact on consumers’ judgment of the usefulness of ORs in SNS.*

**RESEARCH METHODOLOGY**

The design of the questionnaire in this study passes the reliability and validity tests published in many studies. In addition to the basic information of the respondents, the other question items are measured by a seven-point Likert scale; the values are labeled from 1 to 7. The questionnaires were distributed online, mainly through the Qualtrics questionnaire survey tool. A total of 311 questionnaires were collected, and 237 valid questionnaires were obtained after eliminating problems such as short answer time and answers that were too centralized.

We used a PLS-SEM because it imposes only a small number of restrictions on experimental data. PLS has a good interpretation ability even for small samples (Chin & Newsted, 1999). In addition, PLS does not require normal distribution of data (Chin et al., 2003). Therefore, this study adopted this method to evaluate the research model and test the hypotheses.

The demographic characteristics of survey participants are shown in Table 1. In terms of age structure, 73 percent of respondents fell into the 18 to 29 age range. In terms of gender, the ratio of male to female was about 1:1. About 91% of respondents had a college degree or higher.

Table 1: Demographic profile of respondents (N=237).

Measure	Category	N	Percent
Gender	Male	105	44%
	Female	132	56%
Age	18-29	177	75%
	30-39	48	20%
	Over 40	12	5%
Education	High School or Less	21	9%
	College	139	59%
	Bachelor’s Degree	43	18%
	Post Graduate Degree	34	14%

Source: This study.

**RESEARCH RESULTS**

**Measurement Model**

In this study, the reliability of the scale was evaluated mainly through internal consistency. The internal consistency was tested by composite reliability (CR) and Cronbach’s coefficient  $\alpha$  (CCA). In our exploratory study, a CR value above 0.7 and a CCA value above 0.6 were required (Fornell & Larcker, 1981). It can be seen from **Table 2** that the CR and CCA of all covariates meet the requirements, which indicates that the measurement model has good reliability.

Generally speaking, only when the factor loading of all factors is greater than 0.5 can the latent variables be reasonably explained (Chin et al., 2003). It can be seen from **Table 3** that all factor loads in this study meet the requirements of structural validity. In addition, the PLS model’s convergent validity and the difference between validity are based primarily on the average variation extraction (AVE). AVE is required to be greater than 0.5, and the square root of the AVE value is required to be greater than other latent variable correlation coefficients (see **Table 2** and **Table 4**) (Chin & Newsted, 1999; Fornell & Larcker, 1981). Our data met these conditions, showing that there was a good linear equivalent relationship between the latent variables. The measured variables can explain the covariate well.

Table 2: Descriptive statistics for the constructs.

Constructs	Items	CCA	CR	AVE
Helpfulness (Help)	4	0.972	0.979	0.922
Credibility (Cred)	3	0.988	0.991	0.975
Social Distance (Dist)	3	0.986	0.990	0.972
Positive (Posi)	3	0.941	0.936	0.831
Negative (Nega)	3	0.965	0.978	0.935
Accuracy (Accu)	3	0.993	0.995	0.986
Time-Based (Time)	3	0.991	0.994	0.982
Integrity (Inte)	3	0.978	0.915	0.985
Presentation (Pres)	2	0.973	0.982	0.924

Source: This study.

Table 3: Factor loadings and cross-loadings.

	Help	Cred	Dist	Posi	Nega	Accu	Time	Inte	Pres
Help.1	<b>0.964</b>	0.056	0.344	-0.006	0.438	0.693	-0.154	0.305	0.347
Help.2	<b>0.967</b>	0.063	0.361	-0.039	0.455	0.676	-0.137	0.323	0.366
Help.3	<b>0.957</b>	0.057	0.328	-0.016	0.424	0.669	-0.135	0.297	0.327
Help.4	<b>0.953</b>	0.028	0.352	-0.041	0.426	0.682	-0.143	0.305	0.363
Cred.1	0.046	<b>0.988</b>	0.335	-0.136	0.365	-0.411	0.184	0.497	0.338
Cred.2	0.067	<b>0.991</b>	0.347	-0.133	0.379	-0.400	0.210	0.503	0.354
Cred.3	0.029	<b>0.982</b>	0.334	-0.117	0.352	-0.432	0.191	0.493	0.341
Dist.1	0.356	0.341	<b>0.987</b>	-0.174	0.881	0.043	0.067	0.146	0.060
Dist.2	0.341	0.333	<b>0.984</b>	-0.173	0.863	0.024	0.039	0.182	0.053
Dist.3	0.368	0.344	<b>0.986</b>	-0.163	0.869	0.048	0.050	0.142	0.097
Posi.1	-0.011	-0.119	-0.180	<b>0.911</b>	-0.315	0.165	0.265	-0.183	-0.233
Posi.2	-0.028	-0.147	-0.168	<b>0.988</b>	-0.318	0.141	0.270	-0.187	-0.229
Posi.3	0.004	-0.210	-0.193	<b>0.829</b>	-0.331	0.200	0.248	-0.222	-0.234
Nega.1	0.451	0.372	0.264	-0.317	<b>0.969</b>	0.159	0.012	0.046	0.159
Nega.2	0.436	0.335	0.241	-0.286	<b>0.963</b>	0.179	0.032	0.023	0.133
Nega.3	0.429	0.375	0.258	-0.330	<b>0.969</b>	0.152	0.043	0.038	0.160
Accu.1	0.306	-0.411	0.036	0.140	0.167	<b>0.994</b>	-0.041	-0.065	0.034
Accu.2	0.305	-0.402	0.040	0.151	0.161	<b>0.992</b>	-0.020	-0.060	0.038
Accu.3	0.399	-0.423	0.041	0.139	0.174	<b>0.993</b>	-0.026	-0.064	0.038
Time.1	-0.152	0.199	0.050	0.281	0.026	-0.033	<b>0.994</b>	0.070	0.027
Time.2	-0.129	0.201	0.057	0.270	0.042	-0.018	<b>0.988</b>	0.080	0.032
Time.3	-0.157	0.194	0.051	0.268	0.023	-0.035	<b>0.992</b>	0.070	0.029
Inte.1	0.046	0.088	0.335	-0.136	0.365	-0.211	0.184	<b>0.997</b>	0.338
Inte.2	0.029	0.082	0.334	-0.117	0.352	-0.232	0.191	<b>0.993</b>	0.341
Inte.3	0.041	0.033	0.384	-0.173	0.363	0.024	0.039	<b>0.982</b>	0.353
Pres.1	-0.028	-0.147	-0.168	0.188	-0.318	0.141	0.170	-0.187	<b>0.929</b>
Pres.2	0.068	0.344	0.286	-0.163	0.369	0.048	0.050	0.142	<b>0.997</b>

a. Bold number indicate item loading on the assigned constructs.

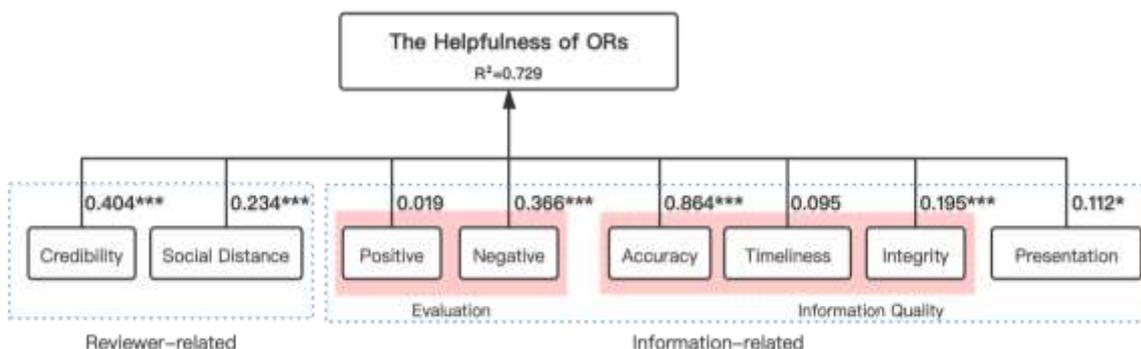
Source: This study.

Table 4: Discriminant validity of constructs – correlations between constructs.

	Help	Cred	Dist	Posi	Nega	Accu	Time	Inte	Pres
Help	<b>0.960</b>								
Cred	0.053	<b>0.987</b>							
Dist	0.361	0.344	<b>0.986</b>						
Posi	-0.027	-0.132	-0.172	<b>0.912</b>					
Nega	0.354	0.373	0.284	-0.321	<b>0.967</b>				
Accu	0.308	-0.415	0.039	0.144	0.168	<b>0.993</b>			
Time	-0.148	0.200	0.053	0.276	0.030	-0.030	<b>0.991</b>		
Inte	0.321	0.505	0.170	-0.184	0.364	-0.063	0.073	<b>0.896</b>	
Pres	0.365	0.350	0.085	-0.234	0.380	0.037	0.029	0.242	<b>0.924</b>

b. Boldface values on the diagonal are the square root of the AVE.

Source: This study.



Source: This study.

Figure 2: The path coefficient of the research model.

### Structural Model

In this study, bootstrapping in SmartPLS 3.3.3 was used to test the t-values' significance of the path coefficient. The results are shown in **Figure 5**. Six of the eight hypotheses presented in this paper passed the significance test. The empirical results show that the credibility of reviewers, intimate relationship between reviewers and readers, accuracy, completeness, timeliness, expression form, and negative evaluation of review information are the main factors that affect consumers' judgment of information usefulness. In addition, the path coefficient reflects the influence of different latent variables on consumers' truest intentions. The results show that negative evaluation has the strongest influence on consumers' recognition of useful information. The influence degree of completeness, timeliness, credibility and social distance on information usefulness decreases in turn.

The prediction ability of the model in this study was evaluated by the coefficient of determination ( $R^2$ ) (Chin et al., 2003). The larger the value of  $R^2$ , the stronger is the ability of the measured variables to explain the changes in the latent variables. Usually,  $R^2$  of 0.25–0.5 is considered to indicate weak explanatory power of a model, and moderate explanatory power is indicated by a value in the range of 0.5–0.75 (Chin et al., 2003). In this study, the degree of explanation of consumer trust intention to the model is 72.9%, which indicates that the explanatory ability of the model meets the moderate explanatory power threshold.

## DISCUSSION AND IMPLICATIONS

### Summary of the Findings

This study discusses two factors related to ORs: the credibility of the reviewers and reviewers' affinity–disaffinity relationship with readers. **Table 5** shows that critics of the professional degree are higher, the more by recognition and the closer the social distance between readers and critics will make his comments play a positive role, which is consistent with our conjecture.

Table 5: Results of hypothesis testing.

No.	Hypothesis	Result
1	The credibility of commenters has a positive impact on consumers' judgment of the usefulness of ORs in SNS.	Yes
2	Social distance (relationship strength) between reviewers and readers has a positive impact on consumers' judgment of the usefulness of ORs in SNS.	Yes
3.1	Positive evaluation perceived by consumers will have positive effects on their judgment of the usefulness of ORs in SNS.	No
3.2	Negative evaluation perceived by consumers will have a positive effect on their judgment of the usefulness of ORs in SNS.	Yes
4.1	The accuracy of comment information has a positive impact on consumers' judgment of the effectiveness of ORs in SNS.	No
4.2	The integrity of the comment information has a positive impact on consumers' judgment of the effectiveness of ORs in SNS.	Yes
4.3	The timeliness of comment information has positive effects on consumers' judgment of the effectiveness of ORs in SNS.	No
5	The presentation form of comment information has a positive impact on consumers' judgment of the usefulness of ORs in SNS.	Yes

Source: This study.

The results indicate that negative evaluation has the relatively strongest impact on consumers' identification of useful information, whereas positive evaluation is not significant for consumers to judge the usefulness of ORs in SNS. Consumers' ability to handle information is limited. To obtain effective content from substantial amounts of information and help themselves make judgments, consumers will tend to ignore many positive comments and choose a smaller number of negative comments to read to understand the problems of the product and reduce the risk involved in product selection. In interviews with consumers, we found that the significance of negative comments would be amplified when the number of negative comments is very small, but consumers are alert to positive comments and focus more on the quality and source of ORs when reading.

In further analysis of the impact of comment quality on OR usefulness, the positive effects of information completeness and accuracy were confirmed, but timeliness was not found to be significant. ORs are a valuable resource and have great significance for consumers to understand the true situation of a product. The integrity of ORs does not mean complete absolute information, but the logical integrity that reviewers show in giving product feedback. Specifically, complete ORs should not just be default positive or bad reviews but answer the question, "Why do I think the product works well?" "In which situations does it work?" Only ORs that fully describe the reason and applicable scenarios have a positive impact on consumers for judging the usefulness of ORs in SNS. The accuracy of ORs relates to the proximity of the ORs with respect to consumer feedback and the actual truth of the product. More and more businesses will engage in *shuadan* ("order brushing") and other

dishonest behavior to cheat consumers with fake ORs or mislead them toward buying products. This severely reduces the accuracy of ORs and has a huge negative impact on consumers with respect to their judgment of the usefulness of ORs in SNS. In further investigations, we found that the impact of timeliness is not significant because consumers would selectively view reviews for different time periods and construct panoramic information about a product or service retroactively to reduce decision-making risk.

As can be seen from **Table 5**, different presentation forms have different effects on the transmission of the usefulness of comment information, among which the mode with pictures and text is more convincing, and the emerging short video mode also has certain positive effects on the transmission of the usefulness of comment information.

### **Implications**

This study took online retail as an example and explored the usefulness of ORs in SNS. The research results enrich the theories that are related to consumer behavior in e-commerce. Many studies have explored factors that influence consumer cognition, but studies on how consumers can fully identify and judge the usefulness of ORs in the SNS environment are few. This study attempts to fill this gap and specifies the factors that consumers use to judge the usefulness of ORs in the SNS environment and the way and structural framework that these factors affect consumers.

The results of this study can help consumers quickly find useful ORs to reduce risk and improve efficiency in an information-overloaded SNS environment. For enterprises, this study can help them better understand consumer choice preferences and the processing mechanism of ORs in SNS. Enterprises can maintain and enhance ORs by improving reviewers' credibility and enhancing OR quality. By showing consumers valuable comment information, extending the time that potential consumers spend in browsing pages, and improving the content of ORs, the enterprise can grow and form good customer relationships.

### **Limitations and Future Research**

This paper analyzed the factors influencing the use of ORs in SNS. Due to limited time resources and the restrictions imposed by choice of the research methods, the research results have certain limitations. First, the larger the sample size, the smaller is the representative error of its statistical estimator and the more convincing it is for the illustration of the results. The sample size of this data was 237, and although this quantity meets the PLS-SEM requirement for the sample number (Chin & Newsted, 1999; Fornell & Larcker, 1981), a larger sample size would have a more positive effect on the error. Second, comment information from empirical studies may alter consumer judgments of the usefulness of ORs in the SNS environment due to factors such as the category of reviewed products and cultural level and personal characteristics of reviewers and readers, especially as the negative comments given by rural consumers and urban consumers are quite different. Therefore, in future studies, the urban and rural geographical attributes of reviewers and readers should be considered.

## **CONCLUSIONS**

In the context of e-commerce, online consumer reviews, which can reduce consumer uncertainty, are increasingly favored by consumers. Studies have pointed out that consumers face the challenge of identifying valuable ORs amid information overload, and it is important for consumers to identify useful online consumer reviews. With the continuous development of SNS, more and more enterprises use social media to close their distance from consumers. Consumers widely use SNS as the release and dissemination channel of OR information. Faced with this new situation, how to identify and judge useful SNS-based ORs is an urgent problem to be solved. With this goal in mind, based on the TPB and the online trust model and by reviewing the literature, this study summarized eight factors that can influence ORs' utility to consumers in a social environment, namely credibility, social distance, evaluation (positive and negative), information quality (accuracy, timeliness, integrity), and presentation. To verify the research framework and hypotheses proposed in this paper, 237 valid data samples were obtained by random sampling. In this study, Smart PLS analysis was used to determine the factors influencing the helpfulness degree of ORs based on SNS. The results showed that in addition to positive evaluation and timeliness, six other factors significantly affected consumers' judgment of the effectiveness of ORs. In addition, accuracy played a leading role in consumers' recognition of useful information. Through the analysis of ORs in a social network environment, this study reveals the determinants of the helpfulness of ORs and explains their mechanism of action.

This study overcomes the limitations of static environments in the field of information reception and explores the effectiveness of real-time dynamic information that is associated with social media, especially live broadcasting platforms. Based on previous academic and industrial views on the quality of information, this study takes into consideration reviewers' trust, the social distance between reviewers and readers, and readers' preference for heterogeneous screening of review information, thus enriching and expanding relevant theories on the validity of review information. It provides theoretical support for consumers to effectively identify review information and merchants to use review information to help sales.

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## **Influencing Generation Z's Kansei Demand for New Tea Purchase Decision and Satisfaction—Research Based on Kansei Engineering**

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### **ABSTRACT**

New tea has entered a prosperous period in China. In this promising market, its main consumer group is Generation Z, which has attracted extensive attention in recent years. Generation Z has distinctive ideas and behavior characteristics in brand recognition, social media, and platform utilization, and their subjective feelings about products directly affect their consumption behavior. In this paper, based on the theory of Kansei Engineering and from both linear and nonlinear levels, this paper uses multiple linear regression and KANO model to study the Kansei demand that affects generation Z's purchasing decisions and satisfaction in the new tea market and gives some suggestions to the current market based on the research results.

*Keywords:* Generation Z, new tea, Kansei engineering, multiple linear regression, KANO model;

### **INTRODUCTION**

New tea is a Chinese drink made of tea leaves, fresh milk, fresh fruits and other natural and high-quality ingredients, and more diversified tea bases and ingredients. Around 2015, China's tea chain industry gradually entered the period of new tea, and new tea became a window for young people to contact traditional tea. Statistics show that even under the influence of covid-19, the popularity of new tea is still not reduced, and the market size of low Chinese new tea will exceed 110 billion yuan in 2021. It is expected to still have a lot of room on this basis and will continue to maintain rapid growth in the next three years. Generation Z, which has attracted extensive attention in recent years due to its significantly different consumption concepts and behaviors from previous generations, is the main consumer group of new tea and has become or will become the main consumer force in each major market. (Liu, 2020).

New tea is new because it has up-to-date technology and brand concepts, with a particular focus on consumer needs. Compared with traditional tea drinks, new tea generally adopts high-quality natural raw materials, "artificial + machine + new food processing technology," and a transparent processing environment to make drinks, which has been recognized by consumers. New tea brands also expand sales channels by building online platforms and combining offline stores, constantly improving store environment and services, carrying out co-branded brand interaction, and launching rich new categories, moreover, through network marketing, content marketing, hunger marketing, Key Opinion Leader (KOL), Key Opinion Consumer (KOC) recommendation and other marketing methods to promote products to attract consumers. These improvements and innovations coincide with the consumption concept and behavior of the new generation of consumers.

In conclusion, it is necessary for tea chain enterprises to pay attention to Generation Z, implement the concept of "customer-centered" by understanding the factors that affect their purchase decisions and satisfaction, constantly improve products and enhance market competitiveness.

### **LITERATURE REVIEW**

#### **Generation Z and Its Consumer Behavior Characteristics**

Internationally, people born between 1928 and 2012 are divided into five generations, which are: Silent Generation, Baby boomers, Generation X, Millennial, and Generation Z. Generation Z refers to those born between 1997 and 2012 (Kristen & Richard., 2019). Although there are many pieces of research on consumer groups at present, considering the particularity of generation Z and the continuous development of the era, the previous research results cannot be fully applicable to the current market. In the past two years, studies on the consumption behavior of generation Z have shown an obvious upward trend, but the total amount is still small. Most of the research content tends to interpret the consumption behavior and consumer psychology of Generation Z and basically stays in the theoretical analysis stage.

Marc Prensky coined the term "digital natives" in 2001, and describes this generation of youth, who were born from the mid-90's to the present. Generation Z are considered the first truly mobile mavens (Anthony Turner,2015),As the result, this

generation is used to with almost no delay time in interaction and communication word wide. This also influences their behavior and perspective in their daily life, including their shopping preference and shopping behavior. According to research, Their consumption choices are characterized by placing equal emphasis on online platforms and offline stores, and they have unique preferences on online shopping (Mulyani et al. ). Generation Z strongly agree that online shopping is fun and give many advantages, such as easiness, save more energy and less effort, and give them easiness to price comparison (Mulyani et al. ).

Generation Z has a high degree of social media behavior, and it needs to combine social media behavior with other consumer information to form a consumer experience in social network (Andrew & Skift, 2017). Jambulingam et al concluded that freedom of expression, entertainment, conformity and exchange of information are the main motivators for using social media networks (Jambulingam et al., 2018). The social roots of Generation Z lie in seeking a sense of belonging and identity and wanting to express who they are through what they buy. In addition, "national fashion" has penetrated into the daily life of generation Z, who pursue the trend of traditional Chinese culture, integrate their spirit with culture, obtain a sense of identity and realize their own value (Liu, 2020).

Generation Z's control over their own consumption and brand recognition are also important manifestations to distinguish them from other generations. In 2021, the spending Generation Z is still in school or just starting out in the workforce, and the survey shows generation Z is more conservative with money than people think. Generation Z values affordable, environmentally friendly products that are not tested on animals. Generation Z is not so much buying the lowest price as it is getting a better deal (John, 2018). But as long as there is a clear difference in quality, they are more willing to spend money on mid-range and luxury brands. In addition, the consumption of generation Z tends to be rational, and the de-branding and functional propositions gradually weaken the customer loyalty and stickiness of big brands. They are more inclined to buy products that bring continuous satisfaction, that is, products that will bring more satisfaction over time (Chen, 2020).

### **Kansei Engineering and Its Application in Consumer Behavior Research**

Kansei quality is a quality characteristic reflected by human's inherent impression and feeling and can reflect customer differences. As a product development technology based on ergonomics, Kansei Engineering combines customers' emotions and preferences with engineering knowledge (Nagamachi & Lokman, 2010), emphasizing that during the process of using products, the direct mental image of the product can be formed through a series of senses such as vision, hearing, touch, smell, and taste, and a mathematical model of Kansei words can be established through human senses and external stimuli to minimize subjectivity (Hartono, 2013).

Kansei Engineering is known as a quality framework with tools and integrated methods. Osgood's method of establishing semantic space SD (Semantic differential) through investigating objects is the basic method of Kansei quality research. scholar pointed out that Kansei engineering can be used to construct a Kansei model that links the overall preferences of customers with the product description and a technical model of the characteristics of the tested products, so as to solve the problems of unclear expression and inconsistent scale of Kansei characteristics encountered in collecting customer needs (Dolgun & Köksal, 2018). Some scholars combine the KANO model, principal component analysis, multiple linear regression, and other tools with Kansei Engineering to study user preferences.

### **KANO Model and Its Application in Kansei Engineering**

KANO model is a tool for qualitative analysis of customer satisfaction, which helps to identify and distinguish product requirements that affect customer satisfaction. KANO model indicates that the relationship between demand satisfaction and consumer satisfaction or dissatisfaction is not necessarily linear, which provides non-linear processing for quality of different attributes (basic quality, performance quality, excitement quality). In order to identify the types of product attributes, Zhao et al expounded the different types of attributes from the perspective of risk attitude through the Kano model based on the impact of product attributes on the overall utility of consumers. (Zhao et al., 2021). Some scholars also use the Kano model and the SERVQUAL framework to classify the elements of customer satisfaction with after-sales service (Sajjad et als,2020).

In the field of Kansei Engineering, Ronald et al. studied the improvement of the quality of the aviation service industry by combining the KANO model, SERVQUAL model, and collection of Kansei words (Ronald et al., 2018). Carmen and Alvaro modified the form of issuing KANO standardized questionnaires, combined the KANO model with Kansei Engineering, and also reduced the number of issuing questionnaires (Carmen & Alvaro, 2011).

### **MLR and PCA Applied in the Study of Consumer Behavior**

Multiple Linear Regression (MLR) is a Linear method to model the relationship between dependent variables and various independent variables. Through using MLR, scholars studied the influence of brand image, service quality, social media marketing and other factors on customers' purchase decisions in restaurants (Putri & Nilowardono,2021). Additionally, Ika et al researched how the brand image, product quality, and promotion simultaneously significantly influence the purchase decision of consumer for Oppo mobile phones. (Ika & Fithri,2021).

Jin, in the study of bottled water appearance, used the SD method and multiple linear regression to build customer preference of bottled water appearance Kansei quality evaluation model, it is concluded that the final purchase decision and the relationship between different Kansei words model to analyze the different proportion of Kansei quality influence customer preference (Jin et al., 2017).

Principal Component Analysis (PCA) converts many interrelated numerical variables into a few independent principal components by dimensionality reduction, if the independent variable is overmuch, generally use the PCA, the use of dimension reduction, several interrelated numerical variables were transformed into a few independent principal components, and then multiple linear regression analysis was carried out. By applying PCA, scholars identified the factors that affect consumers' buying behavior towards goods of consumers' shopping basket to classify them into groups according to their similar buying behavior patterns and to profile each group of consumers. (Lambros & Stavros, 2021). Tian et al. used principal component analysis for a number of associated numerical variable dimensions, turning it into a few unrelated principal components, classifying multiple Kansei words that affect bicycle shape in building a relationship model. (Tian et al., 2017)

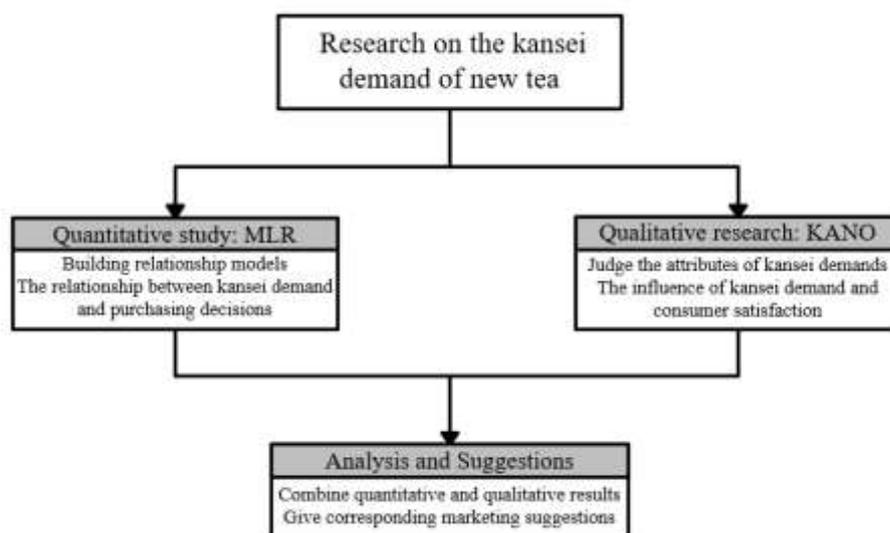
In addition, the combination of PCA and factor analysis can more intuitively classify the dimensionality reduction and quickly calculate the score of each principal component, providing data support for the improved KANO model and multiple linear regression.

## RESEARCH ON THE KANSEI DEMAND FOR NEW TEA

### Research Design

This paper will use Kansei engineering, multiple linear regression method, and KANO model to explore the relationship between the Kansei demand of generation Z and purchase decisions and satisfaction in the new tea market from qualitative and quantitative methods, respectively, and put forward suggestions for marketing improvement through analysis of the research results (Figure 1). The specific research steps are as follows:

- 1) Determine samples, collect Kansei words, and conduct screening.
- 2) Design and distribute five-level Likert scale questionnaires.
- 3) Collect questionnaires for data processing.
- 4) Establish a multiple linear regression model and KANO model.
- 5) Analyze the research results and make a suggestion.



Source: This study.

Figure 1: Research design.

### New Tea Brand Selection

Based on literature research and network data survey, the three brands of HEYTEA, Michelle Ice City, and CoCo Duke are selected as the research objects, taking into account consumer satisfaction, brand market position, consumer market, and marketing strategy.

HEYTEA is one of the leading brands in the new tea market, which is operated directly. After taking into account factors such as a storefront, financing history, influence, and sales volume. The reason why HEYTEA can become a leading brand and a famous online celebrity product lies not only in its huge amount of financing but also in its high-quality raw materials, innovative categories, medium and high-end price strategy, social media publicity, "franchise" channel strategy, and other marketing strategies (Li, 2021).

Michelle Ice City is one of the hottest new tea brands in the past two years. Michelle Ice City has successfully entered the sinking market with a low price of 5-10 yuan per cup. The source of its overnight popularity is the brand's theme song and promotional video, which are popular on social media platforms. On a certain social media, Michelle Ice City has more than ten hot topics, among which the playback volume of a single topic is more than 5.5 billion times, and the total playback volume is nearly ten billion times, which strongly improves the attention of consumers and drives sales. In the process of publicity, Michelle Ice City mainly formulated specific strategies at the three levels of KOL, KOC, and fostering and supporting, and successfully popularized the market by using social media.

CoCo Duke tea originated in Taiwan, with more than 2,000 outlets in 2015, and has become a well-known tea chain brand across all continents of the world. According to the report of IMedia Consulting, Among the new tea brands in 2020, HEYTEA enjoys the highest consumer recognition, accounting for 43%, followed by CoCo Duke, accounting for 34%. HEYTEA stands out among new tea brands by virtue of its excellent social media marketing and various cross-border co-branding and rapidly expands in China by virtue of the franchise model of traditional tea brands.

### Data Collection

Based on consumer behavior and consumer psychology research literature of generation Z, including reports of new tea materials, combined with 30 generation Z for a structured interview and questionnaire survey, set at the beginning of the "taste," "raw material," "price," "brand" and other 26 products experience dimension, collected a total of 434 Kansei words. Through the combination of synonyms and the extraction of commendatory words, 28 dimensions were determined, the number of non-repeating words and high-frequency words was sorted out, and 1 or 2 Kansei words were determined corresponding to each dimension. (Table 1)

A five-level Likert scale was designed, and 28 dimensions and comprehensive purchase intention were set for the three samples. A total of 246 questionnaires were distributed and collected, of which 238 were valid.

Table 1: Dimensions and Kansei words.

Dimensions	Not-repeated words	High-frequency words	Final words
Taste	16	Nice, crisp, smooth	Nice
Raw material	22	Health, safety, abundance, abundance	Health
Price	16	Moderate, practical, accessible	Moderate
Brand	15	Famous, well-known	Famous
Quality safety	15	Healthy, clean, guaranteed	Guaranteed
Catering	16	Delicious, diverse	Delicious
Variety	10	Rich, diverse, more	Rich
Straw	19	Environmental friendly, not easily damaged, not soft, plastic	Environmentally friendly and not easily damaged
Packaging	20	Simple and generous, good sealing, good-looking, delicate	Simple
Membership system	11	More preferential, many concessions, large intensity	More preferential
Queue	15	Short, acceptable, not long, within the limits of endurance	Acceptable
Cost performance	8	High	High
Delivery and distribution	16	On-time, convenient, timely, free	On-time
Production environment	17	Transparent, clean	Transparent
Store environment	20	Clean, fresh	Clean
Joint brand	18	Rich, engaging, loving	Rich
Offline services	16	Thoughtful, good manner, considerate	Thoughtful
Online platform	20	Convenient and fast, perfect	Convenient
Service interactions	20	Satisfactory, comprehensive and humanized	Satisfactory
Communities of Interest	15	Active, fun	Active
KOC	20	More, intimate	More
KOL	21	More, Of reference value	More
Purchasing scenario	15	Unlimited, diverse, rich	Unlimited
Meal replacement	14	plenty, nutritious, convenient	plenty
Innovation	20	Attractive, new, advanced	New and advanced
Environmental protection	13	Green, easily degradable, make a contribution	Green

Personalized	21	Fashionable, tasteful, diverse, joyful, young	Fashionable and young
Brand stand	13	Correct, firm, absolute	Correct and firm
Feedback and after-sales service	9	Timely, patient, considerate	Timely
Brand culture	20	Brainwashing, unique, impressive	Brainwashing

Source: This study.

### Dimension Integration

According to the questionnaire results, the 28 dimensions were integrated into six independent principal components by PCA (based on  $\lambda > 1$ ). These six principal components explained about 65% of the variation of the original dimensions, indicating that they could reflect the meaning of most of the original dimensions. According to the coefficient size, the dimension contained in each component is obtained after comprehensive analysis, and the principal component is named according to the dimension contained. Principal component 1 includes thoughtful offline store service, convenient and fast online platform, satisfactory service interaction, and other dimensions, which are named as functions and services of offline store and online platform. The other principal components and their names are shown in Table 2.

Table 2: Principal components and factors

Principal components	Meaning of principal components	Contained dimensions and correlation coefficients	Accumulative contribution rate (%)	Cronbach alpha
1st	Functions and services of offline store and online platform	Thoughtful offline services (0.740), convenient online platform (0.682), satisfactory service interactions (0.767), transparent production environment (0.595), clean store environment (0.585), timely feedback, and after-sales service (0.628)	37.476	0.867
2nd	Component elements	Nice taste (0.725), healthy raw materials (0.710), guaranteed quality and safety (0.777), Environmentally friendly and not easily damaged straw (0.584), rich variety (0.653), simple packaging (0.381), Delicious catering (0.715)	47.215	0.866
3rd	Price and cost performance	Moderate price (0.852), high-cost performance (0.850)	52.438	0.876
4th	Brand and Connotation	Famous brand (0.130), green environmental protection concept (0.592), brainwashing brand culture (0.131), correct and firm stand (0.317), fashionable and young personalized characteristics (0.531), rich, joint brands (0.110)	57.058	0.757
5th	Additional experience	Plenty of meal (0.247), unlimited purchase scenario (0.123), more KOL recommendations (0.685), more KOC recommendations (0.51), active communities of interest (0.582)	61.077	0.766
6th	Buying experience	More preferential membership system (0.656), Acceptable queue time (0.668), On-time delivery (0.102)	64.645	0.633

Source: This study

### Construction of Relationship Model of New Tea Drinking Kansei Demand

To verify the reliability of the six principal components, the Cronbach alpha of each principal component was calculated. In Table 2, in addition to the buying experience of the product, there are five principal components whose Cronbach alpha are all

bigger than 0.7, indicating that these principal components have high reliability and can be used for the construction of the next relational model.

Multiple linear regression analysis was conducted on the five principal components with high reliability and comprehensive purchase intention (Table 3). The significance of the five principal components was all less than 0.05, indicating that the five components had a significant influence on generation Z's purchase of new tea. Collinearity statistics show that the variance inflation factor (VIF) of all independent variables is less than 10, so it can be considered that there is no collinearity problem among all independent variables in the constructed regression equation.

Table 3: Multiple linear regression.

Principal components	Unstandardized coefficients		Standardized coefficients	t	Significant value	Collinear statistics	
	B	Std. error				tolerance	VIF
Functions and services of offline store and online platform (V1)	0.114	0.014	0.376	8.268	<0.001	1.000	1.000
Component elements (V2)	0.186	0.027	0.313	6.881	<0.001	1.000	1.000
Price and cost performance (V3)	0.259	0.037	0.318	7.003	<0.001	1.000	1.000
Brand and connotation (V4)	0.252	0.039	0.292	6.421	<0.001	1.000	1.000
Additional experience (V5)	0.287	0.042	0.310	6.817	<0.001	1.000	1.000
constant (V0)	-2.396E-15	0.045		0.000	<0.001		

Dependent variable: V (Based on the above views, I would like to buy this new tea)

Source: This study

Based on the above analysis, the following relational model can be established:

$$V = 0.114V_1 + 0.186V_2 + 0.259V_3 + 0.252V_4 + 0.287V_5 + (-2.396E - 15)V_0 \quad (1)$$

Where V represents comprehensive purchase intention, and V1 to V5 represents five principal components, respectively.

In the relational model, the coefficient of *additional experience* is the largest (0.287), followed by *price and cost performance* (0.259), *brand, and connotation* (0.252), but there is no significant difference among the three. *Component elements* and *functions and services of offline stores and online platforms* have little influence on the comprehensive purchase intention.

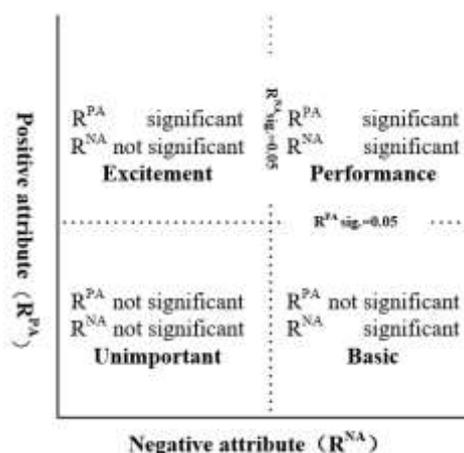


Figure 2: KANO attributes are judged according to positive and negative attributes and significance  
Source: This study

## KANO Attribute of Kansei Demand

### Improved KANO model

In this paper, the form of the KANO standardized questionnaire improved by Carmen and Alvaro is applied (Carmen & Alvaro, 2011). The specific steps and explanations are as follows:

- (1) During the processing of questionnaire data, these attributes are divided into positive attributes (PA) and negative attributes (NA) by factor score. The positive attribute corresponds to the part where the attribute score is higher than average, indicating that the function has been implemented. The score corresponding to the negative attribute is lower than the average score, indicating that the feature is not implemented.
- (2) Calculate the score and significance of Spearman correlation coefficient between positive and negative attributes and comprehensive purchase intention (less than 0.05 is considered significant), and determine the type of this attribute by significance size and a corresponding relationship with positive and negative attributes. (Figure 2)

In FIG. 1, negative attribute ( $R^{NA}$ ) and positive attribute ( $R^{PA}$ ) are taken as axes respectively, and critical significance value (0.05) is used to divide the coordinate system into four parts, wherein:

- 1) Excitement demand: positive attribute is significant, the negative attribute is not significant. When the product does not meet the exciting demand, consumer satisfaction will not decline, but when the product meets this demand, consumer satisfaction will be greatly improved.
- 2) performance demand: both positive and negative attributes are significant. Any measure to improve desired demand will improve consumer satisfaction.
- 3) Basic demand: positive attribute is not significant. The negative attribute is significant. If the product has a low degree of realization of this demand, the improvement will greatly improve the overall satisfaction of users, but the improvement will not be obvious to a certain extent. However, if this demand is not met, consumer satisfaction will be greatly reduced.
- 4) Unimportant demand: the significance values of both positive attributes and negative attributes are less than 0.05. Whether the demand is satisfied or not has little influence on customer satisfaction.

### Determine the KANO Attribute

The five principal components in Section 3.5 are regarded as Kansei needs, and the attributes of each need are obtained by using the KANO model. According to the improved KANO model, each demand is divided into two parts: the average score of less than factor score and the average score of greater than factor score, which is respectively tested for correlation with the comprehensive purchase intention. According to the Spearman coefficient and the improved KANO model, attributes of each Kansei demand are classified (Table 4).

Table 4: Spearman correlation coefficient between perceptual demand and comprehensive purchase intention

Kansei demand	Positive attribute		Negative attribute		KANO attribute
	Coefficient (sample size)	significance values	Coefficient (sample size)	significance values	
Functions and services of offline stores and online platforms	-0.095 (120)	0.031	0.034 (118)	0.397	Excitement
Component elements	0.025 (128)	0.301	0.135 (110)	0.04	Basic
Price and cost performance	0.059 (125)	0.258	0.047 (113)	0.312	Unimportant
Brand and connotation	-0.111 (119)	0.024	-0.096 (119)	0.037	Performance
Additional experience	-0.098 (114)	0.014	-0.033 (124)	0.357	Excitement

### Analysis and Suggestions

Based on the above studies, the regression coefficient and demand attribute results obtained by using multiple linear regression and the KANO model can be obtained (Table 5). According to the quantitative analysis results, the additional experience, price, and cost-performance ratio, brand, and connotation of new tea can greatly affect consumers' decision-making, while the other two have little influence.

Table 5: Comparison of results of multiple linear regression and KANO model

Kansei demand	Multiple linear regression coefficients	KANO attribute
Additional experience	0.287	Excitement demand

Price and cost performance	0.259	Unimportant demand
Brand and connotation	0.252	Performance demand
Component elements	0.186	Basic demand
Functions and services of offline stores and online platforms	0.114	Excitement demand

It can be seen from Table 5 that the coefficient ranks first. That is, the *additional experience* of new tea has the greatest influence on the comprehensive purchase intention, which belongs to the excitement type in the KANO model. Product additional experience includes plenty of meals (new tea can replace the usual meals), unlimited purchase scenario (refers to the different scenarios such as parties, the meeting time to buy new tea), more KOL and KOC recommendations and active communities of interest, the products meet the requirements of the above properties will promote the overall satisfaction of generation Z, There is no discontent when there is no satisfaction. In view of this result, the new tea can be improved as follows:

- 1) Launch new tea containing more meal nutrition, appropriately increase the amount of this category or improve the feeling of satiety after drinking to meet the demand of generation Z for new tea as meal replacement products.
- 2) Enhance the adaptability of new tea in different scenarios. New tea may become the daily drink of generation Z in the future. The brand can launch tea bags, cooperate with different venues, or upgrade delivery services so that generation Z can enjoy new tea in as many scenes as possible.
- 3) Strengthen the publicity of KOL and KOC, and activate the interested community of the brand. Most of the recommendation process of KOL and KOC is carried out on the Internet. Famous Internet celebrities can be selected for product recommendation and marketing, and consumers can recommend to their friends to obtain discounts and other marketing strategies to achieve promotion purposes. At the same time, the brand can also invite more generation Z consumers to enter online interest communities and build an active community atmosphere together with KOL and KOC.

The second demand is the *price and cost performance*. However, according to the KANO model, this Kansei demand will not have an important influence on the purchase decision, including moderate price and high cost-performance ratio. This proves that generation Z while paying attention to cost, will spend a lot of money on products that are worth buying.

The third coefficient of Kansei demand is the *brand and connotation* of new tea, which belongs to the performance demand. This Kansei demand includes famous brands, green environmental protection concept, brainwashing brand culture, correct and firm stand, fashionable and young personalized characteristics, rich, joint brands. Improvement of the above attributes can improve the satisfaction of generation Z. In view of this result, the new tea can have the following improvement measures:

- 1) Firm and correct brand principles and form positive brand values. Grasp the hot spots and contradictory problems of the current era, in the event of major events to clear and adhere to the correct position of the brand, adhere to the principle of unshakable. In terms of values, the brand should dare to publicize positive value output and assume the responsibility of the enterprise.
- 2) Create brand culture advancing with The Times. Pay attention to the cultural construction of their own brands, be good at using information technology to create a brainwashing but profound brand culture. In order to keep up with the consumption trend of generation Z, it is necessary to pay attention to the current hot trends, launch novel marketing strategies according to the fashion trend, or create activities to attract generation Z.

The fourth coefficient of Kansei demand is the *component elements* of the new tea, and it belongs to the basic type attribute. The new tea market is very competitive. In terms of the components of new tea, the vast majority of enterprises have satisfied the elements such as good taste, healthy raw materials, and guaranteed quality and safety. New tea should maintain the current level, grasp the improvement and innovation of competitors in this aspect, observe the market trend, and maintain competitiveness.

The Kansei demand with the smallest coefficient is the *service and function of offline stores and online platforms*, while the coefficient is low but belongs to the exciting type requirements, the results also reflected the complementary qualitative and quantitative results of two dimensions, which are not in quantitative results coefficient of Kansei demand in qualitative aspect also reflects the influence on purchase decisions. Specifically, even though the demand has a small impact on the purchase decision in the multiple linear regression, in the KANO model, customer satisfaction can be greatly improved by satisfying the excited demand, thus having a positive impact on the purchase decision.

In combination with the above aspects and the current actual situation, the low demand coefficient may be due to the fact that most brands have established online platforms in today's new tea market or other markets, and the services and functions of offline and online stores are becoming perfect, which may lead to the low demand coefficient. But combined with the feature of era and generation Z, the technology innovation speed very quickly, the corresponding applied to online and offline platform services also have broad prospects for development, such as the use of AI, all kinds of direct stimulation of sensory organs are after technical innovation is a product of service innovation, and generation Z is very pay attention to the brand and the product for the use of new technology and service innovation, Therefore, if the services and functions of offline stores and online platforms can be improved by means of science and technology, customer satisfaction of generation Z will also be greatly improved.

## CONCLUSION

In the tea chain brand market, as for generation Z's Kansei demand for new tea, quantitative analysis results show that the additional experience, price and cost performance, brand and connotation, component elements, functions and services of offline stores and online platforms of new tea have a decreasing influence on generation Z's purchasing decisions. Qualitative analysis results show that in addition to the elements, and other five kinds of Kansei demand all belong to different KANO attributes, additional experience, functions, and services of offline stores and online platforms belong to the excitement demand, brand and connotation belong to the performance demand, component elements belong to the basic demand, enterprises can provide comprehensive qualitative and quantitative analysis of the results of the marketing plan.

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## Information Security and Firms' Market Value: The Preliminary Analysis

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### ABSTRACT

In the era of information and big data, security events have caused serious impacts on companies' business operations. The paper aims to investigate the impact of information system security events on firms' market value. To do so, this study collects security events data from Chinese mainstream media platforms and newspapers. The event study approach and regression analysis are used to show that the involved companies associated with the events will suffer the loss on its market value. Moreover, the involved companies' characteristics and the events' attributes can also affect the loss caused by these information security events. The findings of the study provide managerial insights for enterprise managers and help them formulate suitable coping strategies for potential events.

*Keywords:* Enterprise Information Systems, Security Event, Event Study Approach, Stock Price, Regression Analysis

### INTRODUCTION

With the advent of the information age and the era of big data, enterprise information systems are playing important roles in companies' business operations. Enterprise information systems can help enterprises greatly improve the efficiency of data and internal resource management, the integrity of data and information, making it easier for enterprises to make objective decisions based on the overall situation. However, security issues with information systems, the widespread application of enterprise information systems have also brought the negative impact on enterprises under spotlights. This is the research focus of this study.

Once an information system security event occurs, the upgrade of the enterprise requires a large amount of time and financial consumption. The enterprise also suffers from the loss of commercial value and potential users. Rahul and Sunil found that some software vendors' stock price and market value will account for about 0.6% after the release of software vulnerability announcement (Telang & Wattal, 2007). Given the complicated nature of listed companies, e.g., volume, industries, product diversity among others, and characteristics of security events, e.g., risk level, type, what loss will information security events cause is not immediately clear. Under certain scenarios, whether this influence will be constrained and affected?

To this end, this study chooses listed companies in China as the research objects, uses a keyword to search for event data from China's mainstream media platforms and news channels. We plan to answer the following two research questions: (1) whether the enterprise information system security event will have a negative impact on the market value of the involved enterprises and cause losses in the short term? (2) Whether event attributes, market characteristics, and the characteristics of the involved companies will restrict this loss and impact?

This study uses the event study approach to observe the fluctuations in the market value of the involved companies after the event. This study also establishes a regression model to further discuss the results of the event analysis and discuss how characteristics of companies and security events would influence such negative impacts. After that, we provide theoretical guidance and suggestions for enterprises to solve the events of enterprise information system security vulnerabilities.

### LITERATURE REVIEW

The event analysis method was first proposed by Dolley in 1933. Dolley used the 95 common stock splitting events from 1921 to 1931 as the research object to observe the fluctuations in stock value before and after the stock split to verify whether the stock split event would be affected. The stock value has an impact. Then at the end of the 20th century, the event analysis method was mainly used to study the performance of mergers and acquisitions and to measure the success of corporate mergers and acquisitions by observing the fluctuations in stock value after the merger. In recent years, the event analysis method has become more widely used. For example, He et al. (2020) used event analysis in COVID-19's Impact on Stock Prices Across Different Sectors-An Even Study Based on the Chinese Stock Market Law studied the impact of the new crown epidemic on China's stock market (He et al., 2020). Rahul and Sunil used the event analysis method in An Empirical Analysis of the Impact of Software Vulnerability Announcements on Firm Stock Price to study the impact of software vulnerability announcements on software vendors' stock prices and concluded that software vulnerability announcements would approximately affect vendors. The market value has an impact of 0.6% (Telang & Wattal, 2007). Similarly, Steven and Burcu also used the event analysis method in Effect of Qatar diplomatic and economic isolation on GCC stock markets: An event study approach to

study the impact of Qatar's diplomatic and economic isolation events on GCC stock prices and explain the economic isolation events. GCC will face a capital outflow of US\$35.4 billion and a decline of US\$21 billion in foreign exchange reserves (Buigut & Kapar, 2020). In general, the event research method has a reliable performance in the research of the stock market, and there are many successful cases, and the event objects tend to be diversified. This provides a lot of practice and experience for the research of this article.

### DATA COLLECTION AND DATA PROCESSING

In this research, 84 events of enterprise information system security reported on China's mainstream media platforms and news channels are selected, involving 18 listed companies in China. We use the official databases and keywords of various media platforms to retrieve events. After the event data retrieval is completed, we further process the event data according to the criteria of event study and the need for data analysis and further summarize the enterprise information system security event category, enterprise information system security event risk level, enterprise response, and attitude to the event. Finally, we need to collect financial data about the involved enterprise and the stock price of the various window periods of the event to observe the impact of the enterprise information system security event on the company's stock price.

#### Information System Security Event Data

Drawing on Rahul and Sunil's research on software vulnerability notifications, we tried to use keyword retrieval to collect the event records from the mainstream media and newspapers: Sina, People's Daily, Guangming Daily, Xinhua, and CCTV. The event data includes articles and reports from Sina, Xinhua, and other media platforms, as well as daily reports from popular newspapers such as People's Daily and Guangming Daily. It also includes graphic data provided by CCTV and CCTV. In order to ensure the timeliness and consistency of the data, we selected the largest media data retention cycle (the length of time each media platform saves data and news) for three years, as the research unit selected the enterprise information system security events from 2018 to 2021 as the research object. In Rahul and Sunil's study, they used "vulnerability and disclosure," "software and vulnerability," "software and flaw," "virus and vulnerability," "vulnerability and patch" to search in the New York Times, Washington Daily News, and Wall Street Journal (Telang & Wattal, 2007). In conjunction with the above research, we use the following terms as search indexes, "system and vulnerability," "platform and vulnerability," "information and vulnerability," "system and problem," "system and defect," "information and leak."

#### Stock Price and Financial Position

We also collect the event-related business share prices and basic financial situation to supplement the research. For the corporate stock price, we use the Python interface in the WIND database quantification tool to count the closing prices of each stock code on each specific date. For financial data on the enterprise, we query from the annual financial statements disclosed by each listed company on the stock exchange.

#### Record Labeling

When we have completed the first round of data retrieval and collection, we will be exposed to a large amount of event data. We must determine two points, 1) all event data is in our controlled and understandable context 2) All events meet the requirements for event analysis and ensure complete and consistent data, so we need to further classify and process the data (Holzmann, 2001).

Regarding the risk assessment of each event, we assume that the coverage of events is objective on the premise that all news reporters are rational. So based on the texts used by event reporters in the description of the event, we can simply categorize and judge the level of risk of the event: if there are words such as "very serious," "very dangerous," and "extremely serious" in the report, we consider the event to be very serious. If no similar adverbs appear in the report, or if words such as "Minor severe" or even "not severe" are used, we consider the event to be generally serious. In our collection of events, a total of 47 events are very serious information system security events, and the remaining 37 events are generally critical.

We found that when words such as "operational issue" and "service interruption" are included, usually the event is an enterprise information system security event caused by a design problem. Words such as "injection" usually code injection events. Words such as "information disclosure," "sensitive information," and "privilege" are often information disclosure events.

When the enterprise information system security event occurs, the enterprise will often respond after a period, explain the event to mitigate the value impairment of the event to the involved enterprise. However, in some special cases, it is also very likely that the involved enterprises will not make any response or explanation of the event. Therefore, we need to distinguish and identify the different response attitudes of enterprises. If we see "alarm," "confirmation," "explanation," "response," "transfer to a third party," and other acts, we think that the enterprise involved in the event has a response. Conversely, if the feedback from the media platform is "unreachable," "unanswered," "unexplained," and "ignored," we think that the involved enterprise has ignored the events.

Some security events may cause serious impacts on people's lives and property, and such events violate the rules of the relevant state agencies, so national regulators, such as the China Securities Regulatory Commission (CSRC) or the China Banking Regulatory Commission (CBRC), will deal with the event. The national regulators may disclose the involved company in the violation, and then national regulators may impose penalties. For example, on March 26, 2021, the China

Securities Regulatory Commission issued an administrative supervision notice for the Haitong Asset Management Trading System for its schedule machine event and pointed out that Haitong Securities did not comply with the relevant prudential principles to prevent risks. Therefore, the security event of Haitong Securities is deeply involved by the national regulatory agency.

### Data Processing and Cleaning

We first delete duplicated event data. For some enterprise information system security events, multiple media platforms may repeatedly report them in a time period. In this case, we only select the report of this event appearing in the streaming media for the very first time. Secondly, we also need to ensure that the "purity" of the event. According to the event study analysis, we need to ensure that the species involved firms are not "polluted" by other events, e.g., the merge or acquisition. Finally, in order to ensure that the whole process of event analysis and regression analysis is in a controlled and unified external environment, we only selected listed companies in China as the research object in this study. Moreover, we only selected the security events directly related to the enterprise information systems, regardless of the chain reaction caused by other management problems and financial problems.

## EVENT STUDY ANALYSIS

### Model Construction

Event study can illustrate the impact of emergencies on financial markets in the short term. Its premise is that the market is rational, so the financial market will give feedback on some abnormal events in the short term. This study adopts an event study approach to study whether information system security events will have a short-term negative impact on companies' stock returns (Mackinlay, 1997). In the analysis of event study, event collections, event announcement dates, event window will be determined, and abnormal return during this period will be estimated to observe events' impact. Regression analysis will be conducted between the market index and firms' actual returns.

In this study, events of interest are information system security events in firms. The time period during which we observe events is the event window. The shortest event window is one day. The first day of the event window is the day of the event, called day 0. Similarly, day  $t$  is the  $t$ -th day after the event, and day  $-t$  is the  $t$ -th day before the event. This study sets the one-day event window for two reasons: (1) A shorter event window can exclude other possible contamination events; (2) A shorter event window would lead to more convincing statistical test results (Buigut & Kapar, 2020). We also need to define the post-event window (from day 0 to day  $n$ ) to demonstrate the events' continuous impact. This study will observe the abnormal returns of the nine trading days after the event. In order to avoid the pre-event leakage, it is necessary to set the pre-event window (from day  $-l$  today  $-m$ ). When calculating the expected return, we will exclude the data in the pre-event window to ensure the stability of the results (Mackinlay, 1997). This study sets  $m = 16$ . In addition to these three windows, we also need to determine the estimated window to calculate the relationship between the company's stock returns and the market index.

### Expected Returns

The expected return of the involved company can be predicted based on the performance of the involved company's stock price gains within the estimation window. Expected income is also called normal income and is the income of involved enterprises under normal circumstances or in the absence of an enterprise information system security event. In order to clarify this normal state, a linear regression method is used to establish a linear relationship with the market index by using the historical return of the company's stock in the estimation window. Using this linear model, we can relatively accurately estimate the expected income of the involved enterprise within the event window. Therefore, the length of the estimation window determines the accuracy of the expected return calculation. Regarding the estimated window length, the window period should not be too long, which will include other events in the estimated window that may affect the stock price of the involved company. The estimation window should not be too short, which may lead to the problem of the small size of data collection (Hendricks & Singhal, 1996).

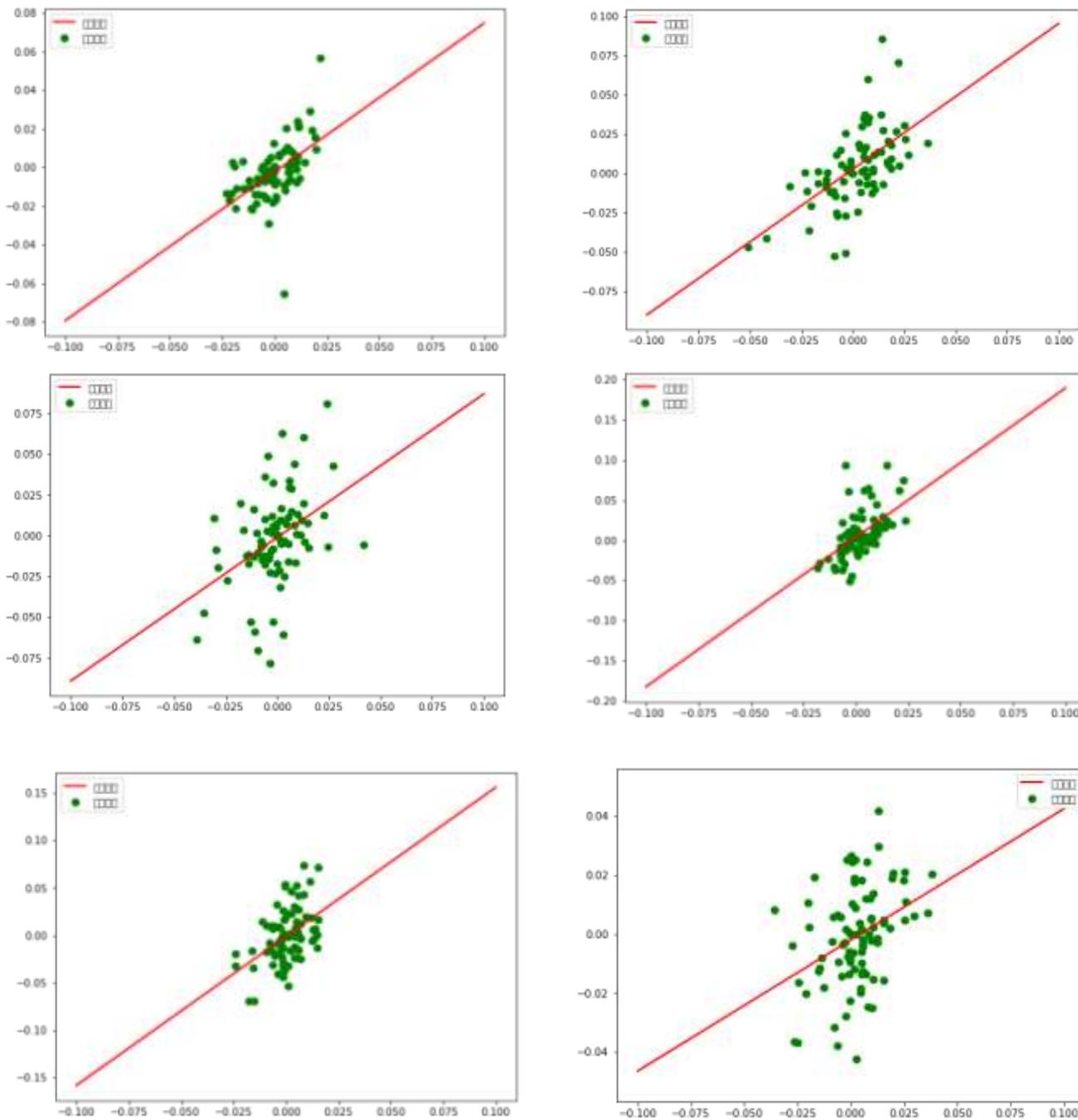
### Market Model

To estimate the expected benefits, this research adopts the Market Model. The important assumption of the market model is that there is a stable linear relationship between the market index and the company's stock returns. The market model can exclude external factors from market returns. These external factors are more sensitive to the stock price of a specific company and can also enhance the convincing power of statistical test results (Benninga, 2014). When there are historical data references for the corresponding survey indicators, the market model can establish a more reliable expected return calculation framework. In the following, we will first introduce how to use the market model to estimate expected returns and use the expected returns to calculate the extraordinary returns of the event window. Then, we also conduct a hypothesis test and a sign test for the cumulative abnormal return (CAR).

In the market model, we must first establish the linear relationship between the market index and the actual income of the company in the estimation window. This linear relationship is as follows:

$$R_{k,t} = \alpha_k + \beta_k R_{m,t} + \varepsilon_k \quad (1)$$

where  $k$  is the event ID of the research subject,  $t$  is the trade date.  $R_{k,t}$  is the actual stock return of the involved company in event  $k$  at day  $t$ .  $R_{m,t}$  is the market index on day  $t$ .  $\alpha_k$  and  $\beta_k$  are the parameters. Figure 1 demonstrates the linear fitting results in some event estimation windows.



Source: This study.

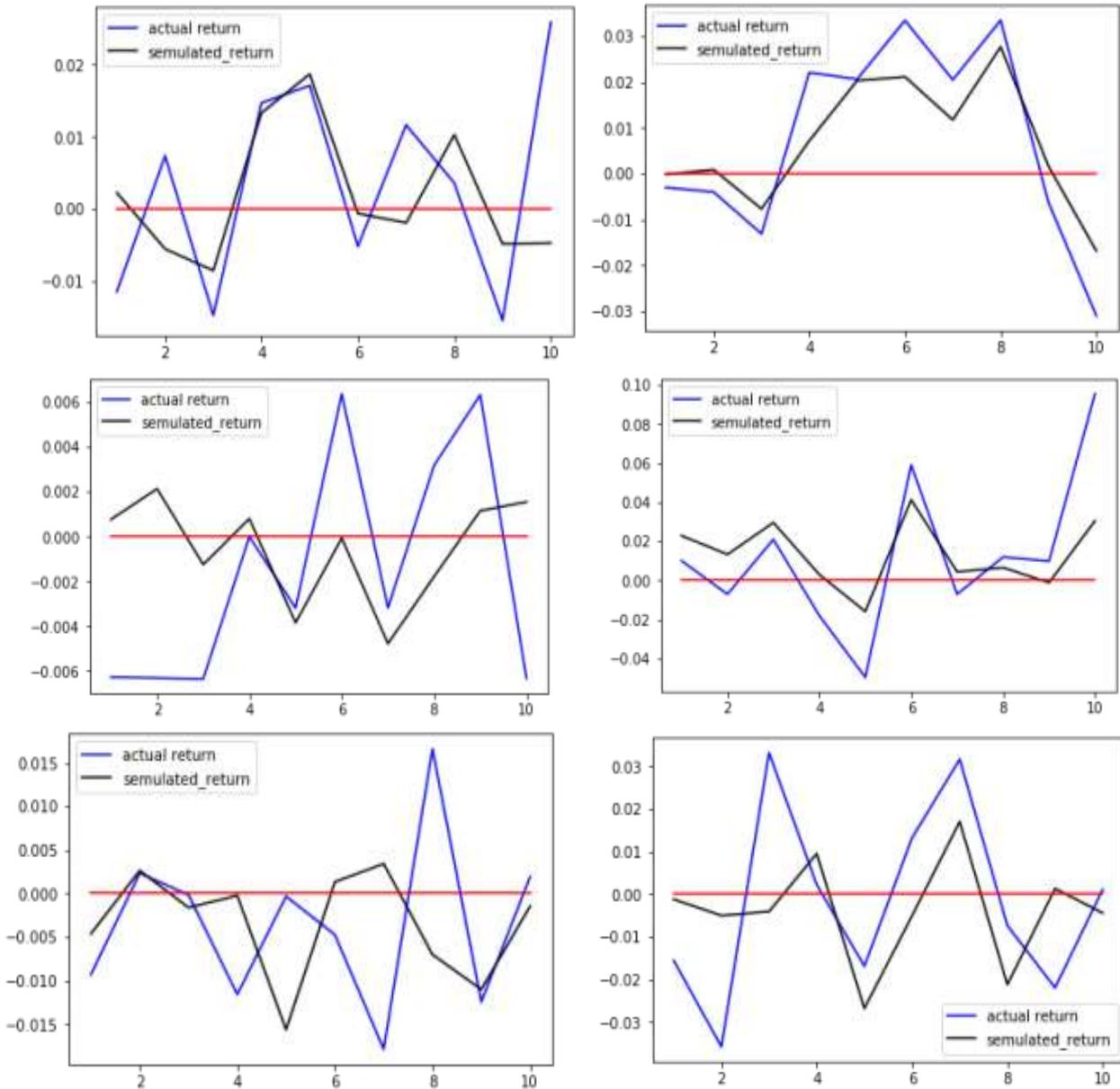
Figure 1 : Linear fitting results in the event estimation window

Then we can use the estimation event window to calculate the expected return in the post-event window using Equation (2).

$$E(R_{k,t}) = \widehat{\alpha}_k + \widehat{\beta}_k R_{m,t} \tag{2}$$

In the equation,  $\widehat{\alpha}_k$  and  $\widehat{\beta}_k$  represent the parameters obtained by OLS.  $E(R_{k,t})$  Represents the expected income or normal income of the involved company in event  $k$  at day  $t$ . Abnormal return is the difference between actual return and expected return as in equation (3).

$$AR_{k,t} = R_{k,t} - E(R_{k,t}) \tag{3}$$



Source: This study.

Figure 2: Event excess return and expected return

To evaluate the total impact of information security events on the stock price of the involved company, we also calculated the Cumulative Abnormal Return for event  $k$  and all events, as in equation (4).

$$CAR_{k,t} = \sum_t AR \tag{4}$$

where  $CAR_{k,t}$  represents the total abnormal return from day 0 to day  $t$  for event  $k$ .

$$CAR_t = \sum_N \sum_{day} AR \tag{5}$$

We use the probability distribution of the residual in equation (1) to represent the probability distribution of the cumulative abnormal return  $CAR$ , so the probability distribution of  $CAR$  can be formulated as:

$$CAR_t \sim N(0, \sigma_{\epsilon_t}^2) \tag{6}$$

Thus, the test statistics  $t\_statistics$  used for hypothesis testing is:

$$t\_statistics = \frac{CAR_t}{\widehat{\sigma}_{\epsilon_t}} \tag{7}$$

Then, we present the result of the  $t$ -test and abnormal returns in the following table.

Table 1: AR and CAR Descriptive Analysis

Day	0	0 to 1	0 to 2	0 to 3	0 to 4	0 to 5	0 to 9
CAR	-0.43	-0.59	-0.51	-0.52	-0.45	-0.36	-0.63
<i>t</i> _statistic	-7.4***	-8.0***	-5.2**	-4.4**	-3.81**	-2.63*	-2.12*

Source: This study.

In the null hypothesis, the test statistic is 0. The large enough t-statistic or the small enough p-value can reject the null hypothesis. We noticed that CAR from day 0 to day nine is negative. After day 1, CAR began to weaken, but this is not a stable trend. For example, on day 9, the cumulative abnormal return is even larger than day 0 and day 1. From a statistical point of view, on day 0 and day 1, the cumulative abnormal return was obviously negative, and it was significant at the level of  $p < 0.05$ . On days 2, 3, and 4, the cumulative abnormal return is still statistically significant at the level of  $p < 0.1$ , but the significance has begun to decrease compared with that on days 0 and day 1. After day 5, although the cumulative abnormal returns are still less than 0, they are not statistically significant. We also use the Wilcoxon signed-rank test to test the sign of the cumulative abnormal return CAR without considering the absolute value of the cumulative abnormal return. We found that the proportion of cumulative abnormal returns less than 0 in the event window is about 63%, which is greater than 50% which is required in the sign test. Therefore, we believe that the sign of cumulative abnormal returns is statistically significantly negative (Fagerland & Sandvik, 2009).

## REGRESSION ANALYSIS

This paper defines the regression model as:

$$AR_k = \alpha X_{i,1} + \beta X_{i,2} + \dots + \gamma X_{i,n} + \varepsilon_i \quad (8)$$

$AR_k$  represents the abnormal return caused by event  $k$ .  $X_{i,n}$  represents independent variables, which can represent  $n$  factors related to enterprise information system security events.  $\alpha$ ,  $\beta$ ,  $\gamma$  represent the coefficients that needed to be determined in the regression analysis. Independent variables are shown in Table 2.

Table 2: Description of Independent Variables

Variables Type	Variable Name	Variable Description
Independent Variables	<i>Com_Size</i>	The volume of the company refers to the size of the company involved.
	<i>Com_Div</i>	This indicator can evaluate the degree of diversification of the company involved.
	<i>Com_Comp</i>	Market competition environment
	<i>Com_GR</i>	Revenue growth rate
	<i>Com_Response</i>	Companies' Response to events. When enterprise information system security events are publicly released, the involved companies may respond to these events, and of course, they may not respond and ignore these events.
	<i>Event_Type</i>	Types of security events in enterprise information systems
	<i>Event_Security</i>	The severity of security events in enterprise information systems
	<i>Event_Dispose</i>	Involvement of national regulatory agencies
Control Variables	<i>Channel</i>	Media platform and data source for an event release
	<i>Year</i>	The time span for the event to be published
	<i>Industry</i>	The industry classification for the events

Source: This study.

### Regression Analysis Result

In the regression analysis, we calculated the correlation coefficient between each variable and the abnormal return and verified its statistical significance. We also calculated the  $R^2$  and p-values of the entire regression model. The  $R^2$  of the regression model is 37%, which is sufficient to explain the abnormal returns of the regression model. The p-value (0.0008) of the whole regression model is low enough (Gabaix & Ibragimov, 2011). It can be seen from Table 3 that enterprise characteristics, enterprise response, and event attributes can adjust the losses caused by information system security events.

Regarding the nature of the event, we found that the disposal of the national regulatory authority has the largest negative impact on the market value of relevant companies. When the national regulatory authorities take some punitive measures, the market value of the involved company will lose 1.4% more. We also found that the type of event and the severity of the event will also cause greater losses after the event, but the correlation coefficient of these two factors is not very significant in our model. We retain our views on the relevance of these two factors and excess returns. Our preliminary analysis suggests that the possible reason is that domestic streaming media platforms still have doubts about the accuracy and objectivity of corporate information system security event reports.

Regarding the response of the company, we found that if the involved company can make a positive response in a timely manner, the loss of its market value can be reduced. We found that the correlation coefficient of Response is 0.014, which means that companies that have not responded to the event or even ignored the event will suffer from an additional 1.4% market value less than those that have responded positively.

Table 3: Regression Analysis Result

Classification	Variables Simple Description	Variables Name	Coefficient
Involved Companies' Characteristics	Market Competitive Environment	<i>Com_Comp</i>	-0.087**
	Revenue Growth Rate	<i>Com_GR</i>	-0.010
	Diversification	<i>Com_Div</i>	-0.007
	Asset volume	<i>Com_Size</i>	-0.005***
	Response	<i>Com_Response</i>	0.014***
Information Security Events' Attributes	Event Type	<i>Event_Type</i>	-0.002**
	Event Security	<i>Event_Severity</i>	-0.001*
	National Regulatory Agencies' Involvement	<i>Event_Dispose</i>	-0.014**
Control variables	Medial Platform and News Channels	<i>Channel_Sina</i>	-0.002
		<i>Channel_People Daily</i>	-0.012*
		<i>Channel_Guang MingDaily</i>	-0.008
		<i>Channel_Xinhua</i>	-0.007
		<i>Channel_CCTV</i>	-0.028**
	Industry Classification	<i>Industry_Finance</i>	-0.039*
		<i>Industry_Internet</i>	0.003
		<i>Industry_Other</i>	-0.006
	Year	<i>Year_2018</i>	0.005
		<i>Year_2019</i>	-0.002
		<i>Year_2020</i>	-0.006**
		<i>Year_2021</i>	-0.012***
P_VALUE	0.0008		
R <sup>2</sup>	0.37		

Source: This study.

For the control variables, we found that the absolute value of the Year correlation coefficient showed an upward trend from 2018 to 2021. The level of statistical significance is also increasing. This shows that investors, markets, and customers are more sensitive to changes in corporate information system security events over time. From the perspective of the industry characteristics, in the financial industry, information system security events will cause greater losses, and the significance level of *Industry\_Finance* is also significantly better than the other two in Industry. This shows that the financial industry has an impact on information system security events.

## CONCLUSION

This research finds enterprise information security events can cause serious negative impacts on involved firms: a loss of 1.93% of its market value or a loss of \$69 million, which are equivalent to the revenue from a certain product line for some enterprises. Thus, it is extremely necessary for companies to pay much attention to their information security investment.

First, large companies in financial service with large volumes need to pay such special attention. In our event data collection, we find that security events in enterprise information systems often bring greater blows to financial service companies. Financial service companies often have relatively bigger asset volumes which will amplify this negative impact. The possible reason is that users and customers of financial service companies are often very sensitive to information security, and their tolerance for such security events is relatively low. Besides, the financial service is not a must for most people. Therefore, once such events occur, users will terminate or abandon the corresponding financial products and services in a very short time.

Secondly, companies need to always pay attention to the corresponding industry dynamics and market operations, and they need to analyze the company's user profile in a timely manner. The switching cost and the user stickiness will greatly affect the losses caused by enterprise information system security events. When user stickiness and switching costs are lower, users will have more choices, and it is easier for them to switch to other companies due to information system security events. Therefore, when an enterprise is in a more competitive market, or its market share has increased substantially in a short period of time, this may mean weaker user stickiness, and the enterprise needs to be more sensitive to information security.

Finally, we find the security state of enterprise information systems is gradually increasing the impact of events. This may be because data and data-related services carry greater commercial value. Often information data is linked to assets, value, and

personal credit. Therefore, with the improvement of information development, especially in some special periods (social emergencies), users will increase their attention to information security, and enterprises should also increase investment in information security.

If the enterprise can provide timely feedback on the enterprise information system security incident, associated firms' loss will be alleviated. On the contrary, if the involved company does not give a reasonable explanation or violates the relevant regulations of the national regulatory agency, it is very likely to cause more serious and bad consequences. Firms are encouraged to explain the incident in a timely manner considering the actual situation after the incident occurs. We believe that it is preferable for the enterprise to self-check the internal process first. If the cause of the incident is the loopholes in the internal control process and the defect of the management model or for problems leftover from system design, companies should acknowledge their mistakes in a timely manner, release patches as soon as possible, minimize user losses, and avoid violating national laws and regulations and causing worse impacts. If, after investigation, it is found that the cause of the incident is an external factor, such as the system supplier's version update is not timely, hacker attacks, etc., the company should also actively respond. After completing the public relations, contact the police in time for filing and forward the vulnerability to CNNVD. Companies are also encouraged to establish a professional, independent information system security emergency response team.

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## **Innovation Quality, Customer Innovation, and Innovation Culture: The Relationship Mediated by Social Media**

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### **ABSTRACT**

Research on the relationship between innovation culture and innovation quality from the perspective of customer innovation is a hot topic in the field of innovation. This article, through the questionnaire survey to 65 innovative enterprises in China, using the structural equation model and hierarchical multiple regression analysis for validating the proposed hypothesis, discusses the relationship between the innovative culture, customer innovation, and innovation quality. The results show that there is a significant positive correlation between innovation culture and innovation quality, customer innovation and innovation quality, and innovation culture and customer innovation. Customer innovation partially mediates the impact of innovation culture on innovation quality, and social media strengthens the role of customer innovation in promoting innovation quality. Customer innovation in culture on enterprise innovation quality partial mediation effect in the process, the influence of the social media to strengthen the customer innovation role in promoting the quality of innovation.

*Keywords:* Innovation culture, Customer innovation, Innovation quality, Social media

### **INTRODUCTION**

Innovation quality is the sum of the quality of each aspect and every link related to innovation, including the product/service level, process level, and enterprise level, which can be reflected through the variables like amount, performance, effectiveness, feature, reliability, timing, costs, value to the customer, innovation degree and complexity, and many more (Haner, 2002). In the increasingly competitive business environment, innovation is the main way for enterprises to seek breakthroughs and maintain their core competitiveness, and innovation quality has become an important indicator and an effective guarantee of the competitiveness of enterprises. At present, most of the corporates in China are the original entrusted manufacturer (OEM), and they are laid in the subordinate status in the international division of labor, with a low-profit rate and low innovation ability. For instance, although the number of filed patents and authorized patents in China has been ranked No.1 in the world for eight consecutive years since 2010, the patents converted into productivity is fewer. Improving innovation quality is an important issue that needs to be solved in China's transformation from a huge to a strong manufacturing nation.

To improve the innovation quality, it's essential to understand clearly the key factors and their working mechanism influencing the innovation quality, and then take effective measures to strengthen the quality management to the innovation. Researches and practices show that one of the key factors influencing innovation quality is the innovation culture in a corporate. Enterprise innovation culture is a combination of both innovative spirit wealth and innovative material form created by the enterprise in innovation activities, with its own features, including innovative values, innovation standards, innovation systems and norms, and innovative material and cultural environment (Castro et al., 2013; Jing, Tang & Han, 2011; Merrill, 2017). Innovation culture fosters innovation and is the premise and the source of all innovations. It can enhance the cohesion of the enterprise and enable the enterprise to have a vigorous spirit of innovation, guaranteeing the continuous improvement of innovation quality. At the same time, it can transmit the innovation concept of the enterprise to the outside world and obtain the recognition and support of customers. To foster an excellent innovation culture is an inevitable requirement for an enterprise to carry out innovation (Dobni, 2013).

Another key factor influencing innovation quality is customer innovation which refers to the activities and patterns of customer-led innovation. With the emergence of the service-dominant logic and the theory of value co-creation, the open innovation mode in enterprises has been popularized (Chesbrough, H., 2003; Chesbrough, H. W., 2003; Gianiodis, Ellis & Secchi, 2010; Lichtenthaler, 2011; Rass et al., 2013), causing the changes of customer's role in innovation. Customers' participation or their independent innovation is common (Hippel, Ogawa & Jong, 2011; Hippel, 2005; Ma, Wang & Wan, 2013; Wang, 2011) and becoming an important factor affecting the innovation quality in enterprises. Studies have shown that customers' knowledge, experiences, and skills are some of the most important sources to improve the innovation ability in enterprises.

Customer innovation is a kind of enterprise innovation model which emerges from and develops with the development of social media technology. Social media, as a product of Web2.0, mainly through a new online platform, i.e., a kind of online interactive media or application programs based on the Internet (Kaplan & Haenlein, 2010), allow users to easily create, edit, and get access to content, with such characteristics as participation, openness, collaboration, interactivity, connectivity, and special clustering property that traditional media such as newspapers, televisions, magazines don't have (Jia & Chen, 2013). It is social media that provide a highly convenient interactive platform for enterprises and customers to exchange information and create value, provide the conditions for customer innovation, and promotes the development of customer innovation.

Some scholars have studied the influence of enterprise innovation culture and customer innovation on innovation quality, respectively (Amabile, 1997; Claver et al., 1998; Dobni, 2013; Hienerth, Hippel & Jensen, 2014), but there are still some deficiencies in the researches on the action path and mechanism between enterprise innovation culture, customer innovation, social media, and innovation quality.

According to the insufficiencies of existing researches and the new changes of enterprise innovation models, and based on the interaction environment on the social media by China's large and medium-sized enterprises, this paper focuses on the following three issues: Firstly, exploring the impact of innovation culture, customer innovation and social media on innovation quality by the empirical research; Secondly, investigating the interaction path and mechanism between innovation quality, customer innovation, social media, and innovation culture; Thirdly, by the analysis and discussion to the empirical results, providing the theoretical basis for enterprises to formulate innovative strategies, and the inspiration for enterprises to manage innovation activities.

## LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

### Literature Review

#### *Innovation quality*

The innovation quality can be measured by the degree to which the product/service provided by innovation meets the customer's requirements and the degree to which the defective products are avoided, i.e., innovation quality is concerned with not only the product/service but also the process directly related to manufacturing as well as the management of the customers of the end products (Yang, 2013). Based on the similarities between innovation quality and innovation performance, Sun (2015) suggested that innovation quality is the internal stimulation of innovation activities and is determined by the particularity of internal contradictions in innovation activities. But the innovation performance describes the scale, degree, and speed of innovation activities and is the arrangement of the permutations and combinations quantity of innovation elements in the space. The relations between innovation quality and innovation performance are essentially the two aspects of the quality and quantity of innovation activities. From the perspective of intellectual property rights, Zhang, Chen & Du (2011) argued that the innovation quality can reflect the innovation capability and can be measured by the authorization rate of the patent and the length of the pay period. Wei (2018) considers that the innovation quality can be measured by the patent rank from the CRIE patent database.

To sum up, innovation quality is a comprehensive concept based on the concept of 'big quality,' covering output quality, process quality, and management quality of the innovation.

#### *Customer innovation*

Under the traditional business model, most corporates used to adopt a relatively closed innovation strategy, and customers were only passive buyers and consumers. With the improvement of customer capacity and network technology, more and more enterprises systematically collect and integrate user information, based on which they conduct innovations (Franke & Piller, 2004), resulting in changes in the customer role, i.e., customer innovation has become an important form of open innovations in enterprises (Gianiodis et al., 2010). Customer innovation refers to enabling customers to participate in the innovation process by enterprises using special methods and strategies (Prahalad & Ramaswamy, 2004). The "customer" in customers' independent innovation is a broad concept, which is not limited to the individual customer but also includes the customer group or the customer community. From the theoretical origin, the concept of customer innovation is the further development and extension of interactive customer marketing and customer relationship management (Wang, 2011).

Hippel (2005) is the scholar who has systematically put forward the innovation theory earlier. He pointed out that in order to meet their own needs, customers suggest new ideas or improvements about the products or services, i.e., customers are the main body of innovation. In terms of the driving factors, on the one hand, the customer can obtain the functional value, the emotional value, the social value, and the economic value by innovation (Kuvykaite & Piligrimiene, 2014), therefore the innovation is a kind of value-driven behavior; on the other hand, customers carry a lot of knowledge and information required by enterprise innovation (Wang, Zheng & Peng, 2012), and their innovation behaviors can help avoid the information stickiness between enterprises and customers, which can effectively complement the enterprises' independent innovation.

In terms of the form of expression, some scholars believe that customer innovation includes two forms, i.e., customers' independent innovation and enterprise-customer cooperation innovation. Customers' independent innovation refers to the process during which customers conduct innovation activities independently in order to meet their own interests and needs (Ma, Wang & Wan, 2013). In this process, value creation is done independently by customers, while enterprises have no close

interaction with customers, similar themes are "customers' personal innovation behavior"(Feng, Lu & Peng, 2012), "customers' independent value creation" (Grönroos & Voima, 2013) and "customers' original value" (Zheng & Wang, 2015). Enterprise-customer cooperation innovation refers to an innovation model in which when enterprises cooperate with the customers whose innovation resources and ability can complement the enterprises, enhancing innovation performance by integrating scattered resources and capabilities (Feng, Li & Zhang, 2013). Some other scholars have enumerated the specific ways of customer innovation, such as sharing information, actively participating, inputting creativity, sharing experiences, suggesting new ideas, sharing risks with enterprises, interacting with other partners, etc. (Wang, 2011).

Although different scholars have different understandings on the connotation, the motive, and the form of customer innovation, by comparing and summarizing, it's found that customer innovation is actually a behavior that customers participate in innovation due to a certain kind of motive, mainly including customers' independent innovation and enterprise-customer cooperation innovation. Customer innovation activities are reflected not only in the feedback or solving problems in the product consumption but also in customers' innovating products through the network platform to achieve a win-win effect of both meeting their own needs and increasing the performance for enterprises.

### ***Innovation culture***

Innovation culture is a constituent part of the enterprise culture and gradually becomes its core. There are two kinds of understanding about innovation culture: One is that innovation culture represents enterprise culture on innovation, mainly referring to the willingness and openness of enterprises towards innovation (Hurt, Joseph & Cook, 1977). It's a culture that rewards innovation and encourages adventure (Dooley & Qsullivan, 2007), or a set of values of advocating, promoting, and protecting innovation behaviors, and an atmosphere of tolerating failures (Jing et al., 2011). Therefore, this is a one-dimensional definition. The other is that innovation culture is a complexion of internal spirits and external manifestations of enterprises, which covers the spiritual, institutional, physical, and behavioral aspects of enterprise culture, specifically including values, codes of conduct, purposes of innovation, infrastructure, and market environment, which supporting innovation (Dobni, 2013; Shui & Xu, 2005). So it's a multi-dimensional definition.

At present, there are few reports on the enterprise innovation culture from the perspective of the customer as a new innovation body. Based on the research paradigm and results about innovation culture, this paper argues that the multi-dimension definition of innovation culture is beneficial to the construction and implementation of enterprise innovation culture, particularly when customers become the main body of innovation. Enterprises should support the innovation resources flowing across the border, encourage customers to actively carry out information feedback, and take the initiative to participate in or carry out independent innovation. From customer innovation, enterprise innovation culture should be composed of two levels, i.e., internal level and external level. The former refers to the spiritual aspect of innovation culture, such as a view, philosophy, or value formed by enterprises towards customer innovation. The latter refers to the institutional, material, and behavioral aspects of innovation culture, in which the institutional aspect contains a series of participation rules, incentive mechanisms, work codes, etc., adopted by enterprises to encourage customers to innovate and guarantee their innovation behaviors. The material aspect refers to the resource supports such as WeChat, microblog, community, customer experience center, maker platform, etc. provided by enterprises to facilitate the co-innovation with customers; and the behavior aspect refers to the actions that enterprises take for customer innovation, such as maker competitions, creative design contest, customer return visit, customer salon, etc.

### ***Social media***

Social media support people's interpersonal communication through the Internet platform and redefine the communication between the enterprises and customers, or customers and customers. Relevant researches indicate that social media have become a major factor affecting customers, including their awareness, information acquisition, opinions, attitudes, purchases, after-sales communication, and evaluation (Mangold & Faulds, 2009). Especially in today's highly competitive market environment, the use of social media can enhance customer participation and significantly affect the performance and the value creation for the corporate (Trainor, 2012), such as through the establishment of online brand communities to make customers an effective source of enterprise innovation (Zhao, Tao & Jing, 2016). The survey shows that in 2010, Fortune 100 companies had an average of 20 different forms of social media for interaction with customers, corporate partners, end-users, and other stakeholders (Rapp et al., 2013). In addition, social media has a positive effect on innovation results, especially the proliferation of new technological achievements (Homburg, Wieseke & Kuehn, 2010).

In summary, social media influence the innovation mode and process of enterprises by promoting interaction between enterprises and customers or within customer groups, which have become an important factor affecting corporate performance.

## **Hypotheses Development**

### ***Innovation culture and innovation quality***

Many studies have confirmed that the innovation atmosphere has a positive impact on innovation behavior and innovation quality (Amabile, 1997). Innovation culture lays a foundation for organizations to seek technological innovation and innovation quality (Apostolos, Panagiotis & Panagiotis, 2017; Claver et al., 1998). To achieve rapid innovation progress, enterprises must pay much attention to the innovation culture according to the principles of behavioral economics (Yan, 2015).

The innovation culture based on customer innovation is a kind of atmosphere, which encourages and supports customer innovation, and is beneficial to improve the innovation quality in the enterprise (Hienerth et al., 2014). Studies have shown that customer authorization as a spiritual incentive has a positive impact on customer innovation (Zhang et al., 2013). Therefore, an excellent innovation culture is a prerequisite for enterprises to improve their innovation capability and innovation quality. Based on the above, the following hypothesis is made:

*H1: Innovation culture has a significant and direct positive impact on innovation quality*

### ***Innovation culture and customer innovation***

The innovation intention and behaviors of the customer are influenced by not only the internal factors such as their perception, demand, evaluation, trust, etc., but also the external factors such as atmosphere, environment, incentive system, platform building, material support, cooperation and mutual benefit, and interaction behavior in the innovation (Wang & Li, 2014). The customer-based innovation environment can encourage customers to interact with each other, solve problems, create value, take risks and make decisions together with enterprises. Qian (2014) found by studying the user communities that the user community with a good innovation atmosphere can exchange various information and knowledge, encourage each other, and make progress together. And the higher the tolerance of the community to innovation is, the more active the users are. Incentive system is an important factor that induces the innovation behaviors of customers because incentives can bring value to customers and stimulate their innovation intention (Chen & Zhang, 2014). Material support also affects customers' willingness to conduct innovation because it provides platforms and ways, as well as resources and technologies for customer innovation. The higher the information level and technical ability of the enterprise are, the more active the customer innovation activities should be (Yao, Jin & Wang, 2013). By stimulating the participation sense of customers, the interactive behaviors on the information platform can promote their emotional contact with enterprises and enhance their trust and recognition to the enterprises, thus, driving them to try to translate their innovative ideas into real products/services and then turn this innovation behavior into a program by repeated experiments and improvement (Gianiodis et al., 2010).

The above shows that innovation culture can directly affect the innovation willingness and behaviors of customers. Since there are both enterprise-customer cooperation innovation and customers' independent innovation, the following hypotheses are proposed:

*H2a: Innovation culture has a significant and direct positive impact on enterprise-customer cooperation innovation.*

*H2b: Innovation culture has a significant and direct positive impact on customers' independent innovation.*

### ***Customer innovation and innovation quality***

Customer innovation can promote the cross-border flow of information, reduce development costs and risks, bring enterprises more innovation sources, and help them achieve the innovation with high efficiency and high quality (Khan & Naeem, 2016; Leavengood, Anderson & Daim, 2014; Zheng, 2010). Focusing on the manufacturing enterprises, Yao & Wang (2011) found that providing information, participating in the design, and co-developing and co-innovating by customers have a significant positive impact on the innovation quality. By investigating the service industry, Feng et al. (2012) claimed that customers' participation in innovation could make innovation specific, reduce the uncertainty of innovation activities, and ensure that innovative services can meet customers' needs better. Moreover, customers' participation in innovation can greatly shorten the development cycle, reduce customers' complaint rate, improve market adaptability of new services, and improve process and result performance of innovation (Yuan, Liu & Li, 2015). To sum up, either as a co-developer or as an independent innovator, customer participation has a positive impact on the product/service innovation of enterprises.

#### ***1) Enterprise-customer cooperation innovation and innovation quality***

Studies have confirmed that enterprise-customer cooperation innovation has a positive effect on the innovation quality in enterprises. For example, the literature on market positioning, relationship marketing, user innovation, and open innovation have shown that, based on customers, by establishing a real-time interaction mechanism and a sharing platform with customers in all aspects, full time and all media, the stability of innovation quality in the planning and the implementing stages can be effectively improved, the success rate can be increased and high-quality innovation results can be produced (Lee, Lanting & Rojdamrongratana, 2017).

Studies have also shown that the main reason for the failure of innovation in many enterprises lies in their inability to understand their customers' needs accurately (Ulwick, 2002) because it's hard to ensure the correctness and integrity of information in the transmission process. Enterprise-customer cooperation innovation can promote the timely cross-border flow of information, and overcome the time delay and the content distortion in the transmission process, thus, ensuring the validity and innovation quality (Vestal, 2014).

In the process of cooperative innovation, enterprises can obtain the information needed for innovation directly from customers. By learning the relevant knowledge from customers, enterprises can improve their innovation capability, reduce innovation risk and improve innovation quality (Wang et al., 2012). Since customers are both the users and developers, enterprise-customer cooperation innovation can not only make the innovative products/services more easily accepted by the market and customers but also shorten the cycle and reduce the cost (Zheng & Xie, 2014). Moreover, customers' participation in

innovation enables them to have fun and feel satisfied, conduct self-realization; and thereby enhance the image perception and brand value of enterprises, which can, in turn, improve the innovation performance (Kuvykaite et al., 2014).

Based on the above discussion, the following hypothesis is proposed:

*H3a: Enterprise-customer cooperation innovation has a significant and direct positive impact on innovation quality.*

## **2) Customers' independent innovation and innovation quality**

Studies have shown that cooperation between customers can bring about high-quality innovation (Qian, 2014). In terms of the innovation quality input, customers, as the users of products/services, are more aware of the functional needs of products/services, so the information input for innovation from them is more effective. In terms of the innovation process, through social media, customers can exchange their experiences in using products, discuss existing problems, share expertise related to products, publish their own innovative achievements, and enjoy cooperation innovation with other customers (Zhang, 2010). In terms of innovation efficiency, the efficiency of customers' independent innovation is generally 2.4 times as high as that of enterprises' innovation alone, but the cost is only 42% of that (Fuchs & Schreier, 2011). The products/services resulting from customers' independent innovation can better satisfy their actual needs, and customers tend to buy the products/services which they have participated in developing. Therefore, it can reduce customer complaint rates and improve the retention rate, increase the market share for products/services and the income of enterprises, and ensure sufficient innovation funds and sustainable and efficient innovative activities.

It can be seen from the above that customers' independent innovation can improve the innovation quality inputs, process, and output. So the following hypothesis is proposed:

*H3b: Customers' independent innovation has a significant and direct positive impact on innovation quality.*

### **The mediating effect of customer innovation**

According to the existing researches, it can be concluded that innovation culture and customer innovation have a direct positive effect on innovation quality, respectively. However, the internal relationship model among the three concepts has not been built yet.

This study makes a further inference on the relationships between innovation culture, customer innovation, and innovation quality, believes that innovation culture has an indirect influence on the innovation quality through customer innovation as the intervening variable, and proposes the following hypothesis:

*H4: Customer innovation plays a mediating role between innovation culture and innovation quality.*

### **The moderating effect of social media**

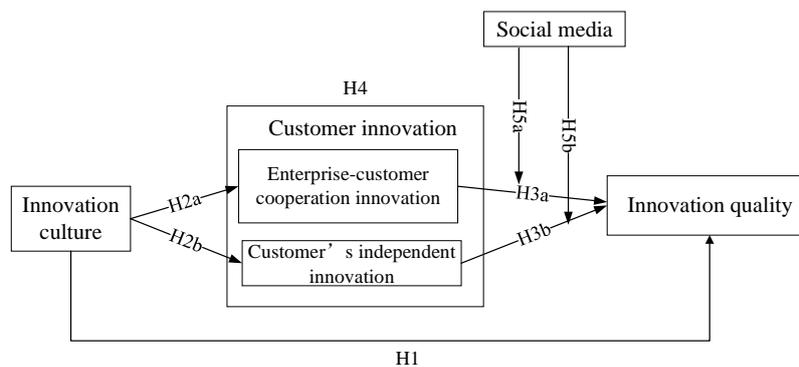
The rapid development of social media has generated a large number of forums and communities, the platform for customers to communicate and learn from each other and innovate together (Zhang, 2010). Social media have become a bridge between enterprises and their customers or customers and customers (Mangold et al., 2009). Many new media platforms, especially the application programs based on mobile intelligent terminals, i.e., mobile phones, have provided customers with channels to learn, cooperate and innovate, and enterprises have more and more interactions with their customers. Enterprises can transmit information to customers by creating social media, and customers can also actively get to know enterprises better. Social media allow customers to freely express their ideas, or let them create together with enterprises, and let them participate in collaborative marketing so that customers become both producers and sellers and transfer the originalities, innovative functions, feedbacks, and so on from offline to online (Chen, Weng & Huang, 2018; Grönroos et al., 2013; Iyer & Katona, 2016; Martini, Massa & Testa, 2013). Interactive behaviors can stimulate customers' participation, and frequent and high-quality interactions can promote customers' input in time, energy, and knowledge and then guide customers to innovate. Social media can help not only in the creation of good suggestions and ideas but also in the sharing and transmission of customers' innovation outcomes between customers and enterprises, which is conducive to the improvement of innovation quality (Yuan et al., 2015).

Thus, the following hypotheses are proposed:

*H5a: Social media have a significant moderating effect on the relationship between enterprise-customer cooperation innovation and innovation quality.*

*H5b: Social media have a significant moderating effect on the relationship between customers' independent innovation and innovation quality.*

Based on the above theoretical hypotheses, a research model on the relationships between innovation quality, customer innovation, social media, and innovation culture is established, as shown in Figure 1.



Source: This study  
Figure 1: Conceptual Framework

**RESEARCH METHODOLOGY**

**Samples**

The innovative enterprises in China were chosen to investigate. The upper-middle managers of these enterprises were chosen as the respondents of our questionnaire because they understand the innovation culture, the innovation quality, and the customer innovation better. The surveyed Chinas' enterprises are mainly private and state-owned, involving machinery manufacturing, automobile manufacturing, metallurgy, Internet, electronics, communications, etc. The variables in the questionnaire were chosen mainly based on the mature scale used in the mainstream literature and modified according to the survey about the enterprises and the experts. Each variable was measured by Likert's 5-point scale.

The variable, innovation culture, based on the scales (Amabile, 1997; Dobni, 2013; Sun & Tian, 2006), was modified into four aspects, i.e., Creative spirit (CS), incentive system (IS), material support (MS) and interactive behavior (IB), with 12 items. Customer innovation, based on the research results (Gianiodis et al., 2010; Kuvykaite et al., 2014; Ma et al., 2013; Wang et al., 2012), was modified into enterprise-customer cooperation innovation (CI) and customers' independent innovation (II), each with 4 items. Social media (SM) was based on the scales (Kaplan et al., 2010; Rapp et al., 2013), with 4 items. And based on analyzing the connotation of innovation quality and the research results( Brown, 2013; Denti, 2013; Yang, Miao & Zeng, 2007);, innovation quality was measured in terms of innovation input quality (IIQ), innovation process quality (IPQ) and innovation output quality (IOQ), with 12 items.

The initial questionnaire was responded to by MBA students at Hohai University and then based on the results and experts' advice, it was modified to form the final questionnaire. In order to avoid the homologous variance, each variable of the questionnaire was distributed and collected several times within certain time intervals. Totally 246 questionnaires were distributed, and 212 of them were taken back. After the screening, 199 valid questionnaires were retained, and the effective recovery rate was 80.9%.

**Validity and reliability**

In this paper, the Cronbach's  $\alpha$  coefficient and the combined reliability (CR) are used to verify the reliability of the scale. The reliability of the scale was evaluated, as shown in Table 1, and the results show that the  $\alpha$  values of the variables are all higher than 0.7, which indicates that the scale has good reliability.

The validity test of the scale consists of convergence validity and discriminative validity. The convergence validity refers to the correlation degree among the items for the same factor and is tested by the average variance extraction value (AVE). If AVE is larger than or equal to 0.5, it is considered that the measure of the variable has convergence validity. The discriminant validity reflects the uniqueness and specificity of the items of each factor and the degree of uncorrelation with other items. The determination of the discriminative validity requests that the AVE of each variable be larger than the square of the correlation coefficient between pairwise variables. (Fornell & Larcker, 1981).

The results (see Table 1) show that the AVE values are larger than 0.5, indicating that the scale has a good convergence validity. By calculating the correlation coefficient between variables, it is found that the R2 values among the variables of the innovation culture are all less than 0.5 and all less than their AVE values. Regarding innovation quality, the R2 value of input quality and process quality is 0.549, the R2 value of process quality and output quality is 0.563, and the R2 value of input quality and output quality is 0.520, also all less than their AVE values, which shows that the scale has good discriminative validity. Customer innovation and social media don't have sub-dimensions. Their discriminative validity is not discussed here. The fitting indexes of each variable of 2 /df, SRMR, RMSEA, TLI, CFI are all within the acceptable levels.

Table 1: Results of validity and reliability test.

Variable	Cronbach's $\alpha$	CR	AVE	$\chi^2$ /df	SRMR	RMSEA	TLI	CFI
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	CS	0.814	0.824	0.612					
Innovation culture	IS	0.767	0.771	0.529	1.822	0.0484	0.064	0.946	0.960
	MS	0.840	0.844	0.644					
	IB	0.802	0.805	0.579					
Customer innovation	CI	0.859	0.859	0.604	0.500	0.0088	0.000	1.009	1.000
	II	0.821	0.823	0.542	2.855	0.0271	0.097	0.961	0.987
Innovation quality	IIQ	0.806	0.811	0.588					
	IPQ	0.883	0.882	0.714	2.683	0.0441	0.092	0.924	0.942
	IOQ	0.889	0.892	0.583					
Social media	SM	0.812	0.824	0.548	2.241	0.0418	0.063	0.897	0.966

Source: This study.

### Correlation analysis

To verify the hypotheses preliminarily, Pearson correlation analysis is used to test the hypotheses of the relationship among the latent variables, and the results, as shown in Table 2, show that significant positive relations exist among all the variables, laying a foundation for afterward verification of the hypotheses.

Table 2. Variable correlation coefficient matrix.

	mean value	standard deviation	CS	IS	MS	IB	CI	II	IIQ	IPQ	IOQ
CS	3.51	0.798	1								
IS	3.01	0.805	.466**	1							
MS	3.03	0.941	.355**	.571**	1						
IB	3.30	0.734	.318**	.318**	.393**	1					
CI	3.38	0.783	.068	.429**	.360**	.235**	1				
II	3.29	0.725	.264**	.541**	.466**	.351**	.616**	1			
IIQ	3.43	0.932	.137	.458**	.425**	.330**	.612**	.617**	1		
IPQ	3.29	0.965	.144*	.489**	.452**	.233**	.682**	.651**	.621**	1	
IOQ	3.42	0.790	.234**	.560**	.470**	.312**	.687**	.708**	.604**	.664**	1

Notes: \*\*, \* Indicates significant correlation at 0.01 and 0.05 level, respectively

Source: This study

## DATA ANALYSIS AND RESULTS

### Hypothesis Test

Statistical analysis software AMOS21.0 was used to test the conceptual model. The fitting results show that the TLI, CFI, SRMR, and RMSEA value is 1.838, 0.891, 0.902, 0.0645, and 0.065, respectively, all within acceptable levels. It indicates that the conceptual model has a good fitting degree. Based on this model, the significance level (P-value) of the path coefficient is used as an indicator of theoretical hypothesis verification. The test results are shown in Table 3. Based on the research model verified above and taking the significance level (P-value) of the path coefficient as the index to verify the theoretical hypotheses, the results are shown in Table 3.

It can be seen from Table 3 that: (1) the T value of the path “innovation culture-> innovation quality” is greater than 1.96, statistically significant at P = 0.05 level, which means that innovation culture has a significant and direct positive impact on innovation quality, so H1 is true. (2) The T values of paths “innovation culture-> cooperative innovation” and “innovation culture-> independent innovation” are both greater than 2.58, statistically significant at P = 0.01 level, which means that innovation culture has a significant and direct positive impact on customer innovation, so H2a and H2b are true. (3) The T value of the path “cooperative innovation-> innovation quality” is greater than 2.58, statistically significant at P = 0.01 level, and the T value of the path “independent innovation -> innovation quality” is greater than 1.96, statistically significant at the P=0.05 level, which means that customer innovation has a significant and direct positive impact on innovation quality, so H3a and H3b are true.

Table 3. Results of the hypothesis test.

Hypothesis	Path coefficient	T	P	Result
H1: innovation culture-->innovation quality	0.156	1.968	0.049	Supported
H2a: innovation culture--> cooperative innovation	0.577	4.407	***	Supported

H2b: innovation culture--> independent innovation	0.447	3.949	***	Supported
H3a: cooperative innovation--> innovation quality	0.669	6.343	***	Supported
H3b: independent innovation--> innovation quality	0.264	2.549	0.011	Supported

Note: \*\*\*  $p < 0.001$

Source: This study

### Mediating Effect Test of Customer Innovation

In order to test the mediating effect of customer innovation, N1 is defined as an initial model, which is a partial intermediary model, and means that the innovation culture has both direct and indirect effects on innovation quality; N2 a complete intermediary model, means that innovation culture can only influence the innovation quality through customer innovation; and N3 means that innovation culture cannot affect the innovation quality through customer innovation. Then the fitting degrees of N1, N2, and N3 are analyzed and compared to identify the optimal model, as shown in Table 4. The significance of  $\Delta 2$  and  $\Delta df$ , as well as the relative simplicity of the model together, determine if the model is optimal. The simplified model can increase the degree of freedom and decrease the fitting degree, but when the 2 value increases very small, the simplified model can be accepted. Table 4 shows that by comparing N2 with N1,  $\Delta 2/\Delta df = 13.736 > 3.84$ , the difference between N2 and N1 is not significant, so the more complex model, N1 is selected; by comparing N3 with N1,  $\Delta 2/\Delta df = 65.362 > 3.84$ , the difference between N3 and N1 is not significant, the more complex model, N1 is selected. Therefore, N1 is the optimal model among the three models, which means that customer innovation plays a mediating role between innovation culture and innovation quality, so H4 is true.

Table 4. Collocation degree of each model.

Model	$\chi^2$	df	RMSEA	SRMR	TLI	CFI	IFI
N1	833.526	449	0.066	0.066	0.889	0.900	0.901
N2	860.999	451	0.068	0.068	0.882	0.893	0.894
N3	898.888	450	0.071	0.079	0.871	0.883	0.884
Result	$\Delta \chi^2$	$\Delta df$					
N2-N1	27.473	2	$\Delta \chi^2/\Delta df = 13.736 > 3.84$ , accepted model N1				
N3-N1	65.362	1	$\Delta \chi^2/\Delta df = 65.362 > 3.84$ , accepted model N1				

Source: This study

The path coefficients in Table 3 show that the direct influence coefficient of an innovation culture to innovation quality is 0.156; the coefficient of an innovation culture to innovation quality through enterprise-customer cooperation innovation is  $0.577 \times 0.669 = 0.386$ , and the coefficient of an innovation culture to innovation quality through customers' independent innovation is  $0.447 \times 0.264 = 0.118$ . The total influence coefficient of an innovation culture to innovation quality is  $0.156 + 0.386 + 0.118 = 0.66$ , while the mediating effect coefficient is  $0.386 + 0.118 = 0.504$ , accounting for 76.36% of the total influence coefficient. It shows that to obtain high innovation quality, enterprises should not only have an excellent innovation culture but also integrate their spiritual culture, system culture, and material culture with customers so as to stimulate customers' innovation enthusiasm, standardize customer innovation behaviors and provide various resources for customer innovation. It also shows that innovation culture by enterprise-customer cooperation innovation has a more significant impact on innovation quality than by customers' independent innovation, and therefore, enterprises should pay more attention to the impact of innovation culture on enterprise-customer cooperation innovation.

### Moderating Effect Test of Social Media

Multiple regression analysis is used to test the moderating effect of social media with enterprise-customer cooperation innovation and as the independent variables, social media as the moderating variable, and innovation quality as the dependent variable. To avoid the multi-collinearity of customers' independent innovation caused by the interactive items generated directly, the independent variables and regulatory variables were standardized. The impacts of variables such as the industry involved, enterprise nature, enterprise size, etc., were controlled when carrying out the data analysis. The analysis results are shown in Table 5.

Table 5. Multiple hierarchical regression analysis—regulatory effect.

		Innovation quality				
		Model 1	Model 2	Model 3	Model 4	Model 5
Control variable	Industry involved	-0.147	-0.007	-0.076	-0.023	-0.044
	Enterprise nature	0.006	-0.023	-0.031	0.039	0.030
	Enterprise size	0.342	0.172	0.175	0.176	0.192
Main effect	Cooperative innovation		0.682	0.063		

	Independent innovation				0.690	0.657
	Social media					
Interactive Effect	Cooperative innovation×Social media			0.116		
	Independent innovation×Social media					0.109
Index	F	9.731	66.251	58.488	73.130	64.172
	ΔF	9.731	56.52	7.763	63.399	8.958
	R2	0.130	0.632	0.646	0.655	0.667
	adj R2	0.117	0.622	0.635	0.646	0.657
	ΔR2	0.130	0.502	0.015	0.524	0.013

Source: This study

Model 3 in Table 5 shows that after introducing the interactive item, enterprise-customer cooperation innovation×social media,  $\Delta R^2 = 0.015$  ( $p < 0.05$ ), indicating that social media play a moderating effect between enterprise-customer cooperation innovation and innovation quality, so H5a is true. Similarly, model 5 shows that after introducing the interactive item, customers' independent innovation×social media,  $\Delta R^2 = 0.013$  ( $p < 0.05$ ), indicating that social media play a moderating role between customers' independent innovation and innovation quality, so H5b is true.

The moderating effect of social media between customer innovation and innovation quality is apparent. Before social media appeared or before enterprises adopted social media, it was difficult for enterprises to interact with users, the users did not understand the enterprises, and the enterprises could not obtain the opinions of the users. So, it's very difficult to conduct enterprise-customer innovations. Without social media, the independent innovation by cooperation between customers and customers is more difficult. It is because of the development of social media technology and the fact that enterprises pay attention to and conduct integration with social media that the model of customer innovation can come into being and develop.

Whether the enthusiasm and the capability of customer innovation can be fully brought into play is closely related to the development of social media technologies and how enterprises pay attention to social media. Although customer innovation has a spontaneous motivation if the interactive technologies of social media are not convenient or unconstrained, or enterprises are not open enough on social media, i.e., enterprises cannot show customers their correct values, lofty missions, and reasonable policies and systems, then, the enthusiasm of customer innovation will be suppressed, and the energy of customer innovation will not be fully brought into play. The emergence and development of new social platforms of customer innovation in the future will greatly promote the quantity and quality of customer innovation.

### Robustness Test

In order to verify the validity of the research results, robustness was tested. The tail-cutting mean method was used for the customer innovation scale (Huber, 1972), and by means of a cutting rate of 25%, i.e., removing the 25% maximum value and the 25% minimum value, the regressive analysis was made again for the remaining 50% data. The regression results show that the regression coefficient changes slightly, and the significance of the key coefficients does not change. Among them, regarding the moderating effect of social media between enterprise-customer cooperation innovation and innovation quality, the regression coefficient for the original overall sample is 0.116 ( $p=0.006$ ), and the value of F, R<sup>2</sup>, and  $\Delta R^2$  is 58.488, 0.646, and 0.015, respectively; The regression coefficient for the tail cutting sample is 0.134 ( $p=0.007$ ), and the value of F, R<sup>2</sup> and  $\Delta R^2$  is 26.388, 0.615 and 0.029 respectively. While regarding the moderating effect of social media between independent innovation and innovation quality, the regression coefficient for the original overall sample is 0.109 ( $p=0.007$ ), the value of F, R<sup>2</sup>, and  $\Delta R^2$  is 64.172, 0.667 and 0.013, respectively; The regression coefficient for the tail cutting sample is 0.124 ( $p=0.007$ ), and the value of F, R<sup>2</sup> and  $\Delta R^2$  is 20.427, 0.553 and 0.059 respectively. All of these show that the robustness of the research results is good.

## CONCLUSIONS AND IMPLICATIONS

### Conclusions

Based on related literature, this paper proposes and validates the theoretical hypotheses and the model regarding the relationships between innovation quality, customer innovation, social media, and innovation culture. The main conclusions are as follows:

- 1) Innovation culture has a significant and direct positive impact on innovation quality, while it has a significant and indirect positive impact on innovation quality through customer innovation. Establishing an excellent innovation culture is the basic condition for the enterprise to carry out customer innovation and improve innovation quality.
- 2) Innovation culture has a significant and direct positive impact on customer innovation, including Enterprise-customer cooperative innovation and customers' independent innovation. An excellent innovation culture can stimulate customers' willingness to innovate and promote the emergence of customer innovation behaviors.
- 3) Customer innovation has a significant and direct positive impact on innovation quality and plays a part of an intermediary role between innovation culture and innovation quality. Customer is an important resource for enterprise innovation. To improve the innovation ability of enterprises, the participation of customers is indispensable.

- 4) Social media play an important regulatory role between customer innovation and innovation quality. They can promote customer innovation and improve the efficiency and quality of innovation.

### Management Implications

Based on the above conclusions, the following management implications can be obtained:

- 1) Innovation culture is the foundation for the creation and development of enterprise innovation, especially customer innovation, as well as the guarantee of innovation quality. Enterprises should pay full attention to the important role of an innovation culture and further explore the general characteristics and the changing trend of contemporary innovation culture according to people's requirements on quality, as well as ideology and moral, social economy, science and technology, management methods, and the development trend of the market environment in the new era. They should conform to the open innovation model, establish the concept of "big quality," and build up innovation value and ideas from the perspective of customers. They should take innovation as the lifeline of their sustainable development and pursue high-quality innovation by establishing a multi-interaction innovation mechanism and a comprehensive evaluation system of innovation. And they must create a cultural atmosphere of advocating, supporting, and developing innovation in terms of organizational system, management system, incentive system, evaluation system, code of conduct, talent introduction and cultivation, achievement transformation, intellectual property protection, and so on.
- 2) Customer innovation is an increasingly important open model for enterprises to carry out innovation activities and an important way to improve innovation quality. Enterprises should strengthen the awareness of and attention to customer innovation, enhance the management of customer innovation, and provide resource support for customer innovation. They can establish incentive mechanisms for customer innovation, create a platform for customers to submit ideas and collaborate on innovation, or establish brand experience stores to collect customers' creativity and suggestions offline. They should provide customers with information, software, consultations, and other supports needed for innovation, and make some techniques and knowledge explicit and simplify the complex procedures in the developments.
- 3) Cooperation and innovation between enterprises and customers are essentially an information interaction behavior. Social media are indispensable technology platforms for customer innovation. The advancement of social media technology continues to promote innovation activities. Enterprises should make full use of social media to enhance their relationship with customers. Nowadays, the emergence of various social networking sites and new media has transformed the traditional binary relationship such as B2C and C2C into a three-way Internet relationship among customers, enterprises, and potential customers. Social media play an important regulating role in customer innovation and innovation quality. Therefore, enterprises should create their own corporate websites, official Weibo, official WeChat, customer forums, and other social platforms by focusing on creating, maintaining and updating, and constantly improving the conditions for an interaction.
- 4) The innovation activities, especially in small and medium-sized enterprises, cannot be separated from the guidance and support of the governments, just as they support the joint innovation of enterprises with universities and scientific research institutes. The governments should guide and support customers to participate in the innovation activities of enterprises by formulating laws and regulations, breaking monopolies, and standardizing market order, especially in intellectual property protection, independent innovation project approval, and achievement transformation.

### Limitations

This paper does not examine the impact of the industry nature on the research results and only studies the moderating role of social media between customer innovation and innovation quality, but not between innovation culture and customer innovation. It merges the spiritual, institutional, physical, and behavioral culture of innovation into a second-order variable of an innovation culture and fails to reflect the impact of different levels of innovation culture on customer innovation and innovation quality. It cannot consider the endogenous problem of enterprise culture, i.e., the reaction of customer innovation and innovation quality to innovation culture and the reaction of innovation quality to customer innovation. It fails to consider the endogenous problem of enterprise culture, i.e., the reaction of customer innovation and innovation quality to enterprise innovation culture and the reaction of innovation quality to customer innovation—all of these need to be made up in future researches. In addition, it also has great theoretical and practical significance to study the impact of innovation culture on innovation quality by taking employee innovation and supplier innovation as intermediate variables, and the impact of customer's own factors, such as customer demand, customer perception, and customer preference, on customer's innovation intention, innovation behavior and innovation quality. Studying customers' own factors, such as customer demand, customer perception, and customer preference, will further deepen the research on the relationship between customer innovation and innovation quality and comprehensively understand the impact of customer innovation on innovation quality. These can be used as future research topics.

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## Is Natural More Beautiful? Research on Natural Product Preference Based on IAT

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### ABSTRACT

This study aims at testing consumers' preference for natural products behind buying decisions and exploring moderating factors as rural life experience and gender for their effects on natural preference. With the help of implicit association theory, we used IAT (Implicit Association Test) to measure the remoteness between positive words and natural products to identify whether there is an implicit preference. And we examined the moderating effects through online research in China. Three hundred one participants have joined this experiment. The result shows that Chinese consumers do have an implicit preference for natural products. When consumers had more than five years of rural life experience, their preference for natural products was significantly higher than those without. However, gender did not make any significant difference, except that women have more preference for nature in the field of food. Our conclusion not only enriches the understanding of consumer behavior but could also help product designing and development, particularly in the food area.

*Keywords:* Natural products, natural preference, implicit association, rural life experience, gender difference

### INTRODUCTION

Social psychologist Rozin and other scholars have found that for most people in the western world, natural food and natural medicine are better than processed food and drugs (Rozin *et al.*, 2004; Rozin *et al.*, 2012), and natural landscape is better than man-made landscape (Hartig & Evans, 1993; Purcell & Lamb, 1998). People generally show an attitude that "*natural things are better than unnatural things*," even in terms of negative events. They also thought that natural injuries are more acceptable than man-made ones (Williams & Hammitt, 2001). Even though there is no obvious difference in physical and other attributes are the same (Overvliet & Soto-Faraco, 2011), natural products are still considered as better taste, more valuable nutrition, and higher safety. Thus they would be more likely to be chosen when consumers are making purchase decisions (Franchi, 2012; Dominick *et al.*, 2018). Hence the natural preference theory was born, which represents the idea that people generally prefer things that are natural to those that have been interfered with.

Humans' preference for nature has existed for a long time. However, the preference is not to stay still. In the industrial revolution ages, the development of industry had grown rapidly, and many new products were produced to change people's life hugely. Thus, people's attitude towards nature has changed from awe to domination since industrial products could perfectly fulfill their large demand. With the development of the economy and the awareness of caring about nature and environmental issues, people begin to return their affection to nature again. Natural preference has been verified to be widespread in modern Western countries (Hemmerling *et al.*, 2016), but studies on natural preference in eastern and developing countries are very limited.

Although Basha *et al.* had done their survey on organic food preference in India (Basha & Lal, 2019) and Cheung and Hsu also had completed their conclusions on organic food preference in Hong Kong (Cheung *et al.*, 2015) and Taiwan (Hsu *et al.*, 2016) respectively. There is no systematic inductive exploration of natural product preference as an individual concept. Since the industrial development process is relatively later and slower than that of the west, the degree of natural preference in China may differ, as one of the typical examples of developing countries in East Asia. For example, Yip has found that Hong Kong consumers have different preferences for mainland organic food due to other reasons (Yip & Janssen, 2015). In addition, there is an unavoidable question laid between the translation from English to Chinese. When Chinese people talk about nature, it probably means the landscape, such as the sky and waterfront. So, whether there is a "natural preference" among domestic consumers is still a subject to be verified.

Combined with the above considerations, this study will develop the hypotheses and theoretical model on the basis of the literature review of knowledge sharing in the context of natural preference. Furthermore, the consumer data obtained from the experiment will be used for analysis and discussion later. Moreover, the theoretical and managerial implications will also be proposed to provide some references for other scholars or managers.

## LITERATURE AND HYPOTHESES

### Natural Products and Perception of Naturalness

FDA once stated that it was difficult to define the standard of natural products from the perspective of food science since most so-called natural products seen in common commercial situations involve some degree of processing and are no longer purely indigenous products. That is, the concept of the natural product is widely misused in commercial products by the industry (Czarnecki, 2016) and understood by consumers in different countries from different perspectives (Berry *et al.*, 2017). From the perspective of semantics, the concept is also expressed differently in different countries. Naturalness is an ill-defined concept both in terms of its objective definition as well as in terms of subjective sensation.

In terms of the perception of naturalness, naturalness is a dimension that reflects the authenticity of products (Beverland & Luxton, 2005), and it is an ill-defined concept both in terms of its objective definition as well as in terms of subjective sensation (Overvliet & Soto-Faraco, 2011). If a product has shown perceivable naturalness, consumers will consider it more credible (Lunardo & Saintives, 2013). As human beings have had an innate preference for nature for a long time (WILSON, 1984), products that are rich in naturalness and able to trigger natural association are favored by more consumers. Based on the literature reading and interview results of "nature" at home and abroad, this study defines natural products as "*products from or originating from nature, rich in natural connotations and capable of triggering natural associations.*" According to this definition, "green products," "organic products," and "environmental protection products" commonly seen in the Chinese consumer environment are all "natural products," originating from nature and rich in natural connotations, and falling within the category of natural products defined in this paper.

### Implicit Attitude and Implicit Association Test

Due to different social motivations, people often choose to blur or hide their true attitude when expressing their preference for a certain point of view or thing. Thus individuals' self-reported attitudes may be suspect. (Fazio *et al.*, 1995). Implicit attitudes, on the contrary, are introspectively unidentified (or inaccurately identified) traces of past experience that mediate favorable or unfavorable feelings, thought, or actions toward social objects. (Greenwald & Banaji, 1995), which is also called a "bona fide pipeline" for attitude measurement (Fazio *et al.*, 1995). Although the participants themselves are not aware of it, implicit attitudes do exist and can be measured through Implicit Association Test (Banaji & Hardin, 1996). (IAT, the same later)

Natural products have always been considered morally or ethically superior (Honkanen *et al.* (, 2006). Hwang found that consumers had higher purchase intention for natural food due to self-presentation motivation and ethical self-identity attached to natural food (Hwang, 2016). Carrigan also proposed that consumers who choose natural products would owe partly to their personal moral beliefs rather than moral consumption (Carrigan *et al.*, 2004). The purpose of this study is to identify consumers' real natural product preferences rather than socialized processing attitudes. So as to explore consumers' real implicit preference attitudes more effectively, we choose to use IAT to effectively reduce the influence of consumers' active hidden or converging preference attitudes.

In this study, the e-Prime program was used to write an IAT program for natural product preference. Two groups of words with positive or negative attributes and two groups of words representing the natural product and the non-natural product were designed for experiments. Participants were required to judge and connect them in a short time, and the D-value representing the closeness of concept words and attribute words was calculated by the response time difference between compatible and incompatible joint tasks, then we summarized the implicit attitude of consumers towards natural product preference. Based on the arrangement of previous studies and the foregoing discussion, this paper puts forward the hypothesis:

*H1: At the implicit attitude level, Chinese consumers have a positive preference for natural products.*

### Life Course Theory and Rural Life Experience

According to the life course theory, an individual's life course is a sequence composed of multiple life events (Elder *et al.*, 2003), which emphasizes that the life course moves forward in a non-linear form, including pause, cycle, and direction change (Pearlin & Skaff, 1996.), and these adaptation processes will lead to changes in people's thoughts and behaviors. The life-course theory states that people's attitudes and behaviors at any time and stage are influenced by three change mechanisms: norms, pressures, and human capital (Elder, 1998; Blossfeld & Huinink, 1991). Norms represent the transformation of people's roles and behavior patterns in the process of socialization. For example, when a young girl becomes a mother, her attitude towards life will change greatly due to the birth of offspring, and the process of adapting to the new role is called norms. Stress refers to behavioral and psychological changes that occur when people adjust their behavior to a routine when they encounter an event such as the death of a beloved person. Human capital emphasizes the influence of individuals' past linking resources, abilities, and knowledge on their future choices (Blossfeld & Huinink, 1991; Frytak *et al.*, 2003). These mechanisms are simultaneously influenced by the time of event occurrence, people's initiative (i.e., people's choice of their own life), society, and historical background (Elder Jr, 1998).

According to the life course theory, consumers with different life courses have different preferences for natural products. From the perspective of human capital, consumers who have lived in rural areas in the past will have more preference to embrace nature because of "intimacy" and "nostalgia." However, consumers who have no rural life experience and have been brought up in cities are more inclined to choose the common "unnatural scene" in their growing-up environment. Therefore, we speculate:

*H2: Consumers' rural life experience positively moderates their preference for natural products. Consumers with rural life experience would have a stronger preference for natural products.*

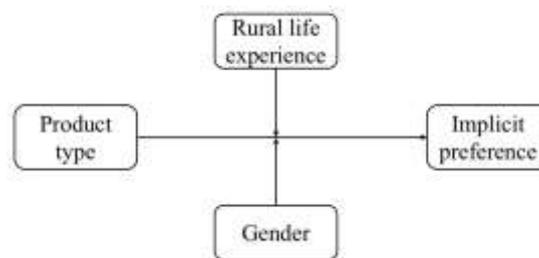
### Gender Difference

When people are processing information, women tend to pay attention to details and take a comprehensive approach; men, on the other hand, tend to use selective heuristic processing for information and pay less attention to details of information, resulting in perceptual differences (Meyers-Levy & Maheswaran, 1991). At present, there have been a large number of studies on women's choice of natural products. For example, Shin has verified that there is a positive correlation between buying organic food and femininity (Shin & Mattila, 2019). To avoid being considered as related to femininity, men will engage in non-environmentally friendly compensatory behaviors after choosing organic food. Tindall also found that women tend to reuse and recycle items more often than men (Tindall *et al.*, 2003). In general, women tend to show more pro-environment behaviors than men (Zelezny *et al.*, 2000) and hold stronger beliefs about the health of organic food (Akhondan *et al.*, 2015).

According to the Sex-Role theory, due to the needs of social structure, women are encouraged to express more, care more, and take care of others, while men are encouraged to analyze problems and do hands-on operations (Putrevu, 2001). At the same time, women are also encouraged to complete task goals and social goals to achieve altruistic value (Eagly *et al.*, 1990). Thus, it is more likely for women to choose natural products with low risk and low harm and produce more psychological preference. Therefore, this study speculates that:

*H3: Consumer gender has a moderating effect on preference for natural products. Women would have a stronger preference for natural products than men.*

Based on the above hypotheses, our research model is shown in Figure 1.



Source: This study.  
Figure 1: Theoretical Model.

## STUDY(A): EXAMINE WHETHER PREFERENCE FOR NATURAL PRODUCTS EXISTS

### Measurement

This paper first uses an offline IAT to examine consumers' natural preferences. Before proceeding with the formal IAT study, we first conducted a pre-test to select the most common words (both abstract descriptive words and specific products) that fit with customers' expectations towards natural products and unnatural products. Next, we carried out an online experiment to identify consumers' preferences towards different types of natural products.

### Pre-test

In order to make material words used in the formal experiment conform to the majority of the consumers' minds, we first conducted brainstorming. After picking up 15 selected vocabularies representing natural products and 15 selected vocabularies representing unnatural products, as concept words, we then sent out an online questionnaire through social media. All participants were asked to select six words with the highest and lowest naturalness perception, respectively. According to the voting results of 173 people (89 female), the following two groups of words were finally determined, with a total of 12 words, as shown in Table 1.

Based on Li's summary of the reasons for consumers' preference for natural products (Li & Chapman, 2012), the IAT experiment planned to use adjectives representing emotion and evaluation words as attribute words to show positive or negative attitudes so that subjects could connect concept words with them. We first selected 36 words describing emotion or evaluation tendency and then invited ten undergraduates (6 female) to screen these words. After removing some neutral and inappropriate words, we finally obtained 24 tendency words (among which 12 are positive and 12 are negative), as shown in Table 2.

Table 1: Concept Words.

Natural products	Unnatural products
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Aloe gel	Reinforced concrete
Cotton and linen garments	3D-printer
Hand-made carpet	Button batteries
Cany chair	Robot arm
Log furniture	Computer
Pressed peanut oil	Motor car

In addition, it should be noted that the authors have used the Chinese translation versions of the above for this study in China. So, there may be different semantically.

Table 2: Attribute Words.

Emotion tendency		Evaluate tendency	
Positive	Negative	Positive	Negative
deserve to be loved	should be hated	peaceful	irritating
like	hate	Beautiful	ugly
relaxed	anxious	comfortable	uncomfortable
devoted	indifference	safe	dangerous
joyful	sad	healthy	unhealthy
excited	bored	kind	evil

### Design and Procedure

In the formal experiment, we used a 2 (subject type: Natural products vs. Unnatural products)  $\times$  2 (descriptive words: Positive vs. Negative) between-subject design, and the participants were required to sit down in a quiet and undisturbed area, such as library reading room, computer room, and other confined spaces. They should sit in the same position away from the computer and complete the IAT experiment independently according to the experimental instructions printed in advance by the investigator and the operating instructions provided by the program. If they were ready, participants would press the tab button. All participants would be rewarded free tissue sets or free dining coupons after completing the experiment.

The words presented on the screen were randomized for each participant. Their task was to press the key labeled different attributes in each task as quickly as possible to indicate his or her judgment of the word. They were instructed to maximize the speed and accuracy of their responses while completing the tests shown below in Table 3.

Table 3: IAT Task Sequence.

Test Sequence	Task	Label	
		F	J
1	Recognition of attribute words	Positive	Negative
2	Recognition of concept words	Natural products	Unnatural products
3	Compatible conjoint task (practice)	Positive & natural products	Negative & unnatural products
4	Compatible conjoint task (formal)	Positive & natural products	Negative & unnatural products
5	Recognition of concept words	Unnatural products	Natural products
6	Incompatible conjoint task (practice)	Positive & Unnatural products	Negative & natural products
7	Incompatible conjoint task (formal)	Positive & Unnatural products	Negative & natural products

After completing the IAT experiment, participants were also required to fill out a questionnaire including some personal information.

### Participants

A total of 42 subjects participated in this experiment in Changsha, China. There were 20 male subjects and 22 female subjects, mainly aged from 18 to 25 years old (66.7%), ( $M = 25.28$ , Median = 22,  $SD = 7.16$ ); 14 subjects who had lived in urban areas for a longer time, and 28 subjects who had lived in rural areas for a longer time.

### Measures

**Manipulation.** In the IAT experiment, participants were asked to press the keyboard button in response to the different words randomly displayed on the computer screen. When the subjects were stimulated by these words and asked to react quickly, they needed to process and respond in their brains and judge to press the correct button. It is generally believed that in the compatible conjoint task, the relationship between concept words and attribute words is relatively close (at the level of implicit attitude cognition), and the discrimination at this point is more dependent on automatic processing so that the difficulty of completing button action is lower. That's to say, the response speed is faster, and the response time is shorter. In incompatible joint tasks, the relationship between concept words and attribute words is relatively loose or opposite, which leads to a cognitive conflict of the subjects, so that the linking process would be more complex, resulting in spending more time on completing the button action.

According to such principles, the responses of subjects in completing various tasks were collected to calculate the D-value representing whether the IAT effect was significant for subsequent analysis.

**Dependent Variables.** The reaction time from a new word shown on the screen to participant made a press was automatically collected by the e-Prime program and then analyzed by SPSS23.0. The improved D-value calculated method proposed by Greenwald was adopted for data processing (Greenwald *et al.*, 2003). Compared with the traditional D-value calculation method, the improved method can better reflect the potential association strength, evaluate the relationship between association strength and other variables, and better reveal that individual differences are mainly caused by association strength rather than other variables.

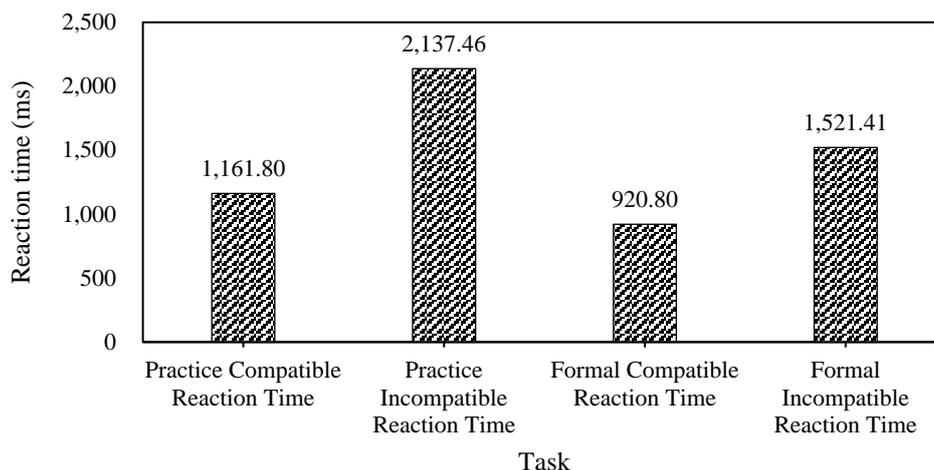
**Moderating Variables.** For the moderator variable of the preference for natural products, we've decided to focus on gender and rural life experience. In order to make the variable clear, participants only needed to answer whether they lived in the countryside or in the city longer. Anyone who has lived in the countryside for more than five years should tick one selection box to show they are different from the city-living ones.

**Other Measures.** We chose demographic information as the control variables for this study, including age, education, professional career.

## Result and Discussion

### Manipulation Check

From the result shown in Figure 2, we can know intuitively that participants spend more time on incompatible conjoint tasks than on compatible conjoint tasks in both practice tasks and formal tasks. Also, we can make a preliminary judgment that it is indeed more difficult to associate natural products with negative words than unnatural products with negative words.



Source: This study.

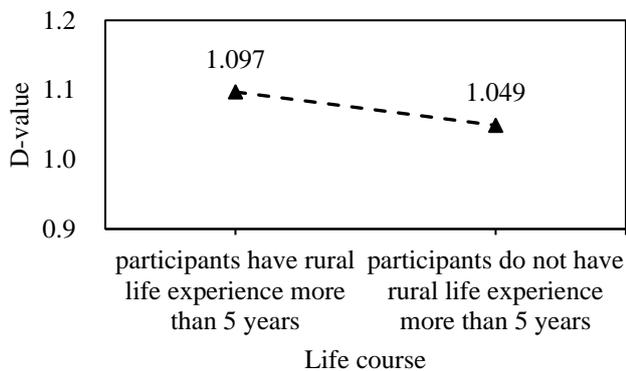
Figure 2: Reaction time in study1(a).

It is generally believed that when the absolute value of D-value is less than 0.15, the IAT effect is not obvious; when the absolute value of D-value is greater than 0.35, there is a moderate IAT effect; when the absolute value of D-value is greater than 0.65, there is a strong IAT effect (Greenwald *et al.*, 2003). The D-value obtained by the IAT experiment is 1.081 in study1(a). That is, in terms of a single choice of products in the combination, consumers have a strong implicit preference for natural products. Any difference between rural life experience and gender is shown in Figure 3 & Figure 4. No matter whether they have rural life experience for more than five years and no matter they are female, their D-value both exceed 0.65, suggesting the strong IAT effect. The difference between gender seems to be significant, for the D-value of the female is 1.24 while the D-value of the male is 0.926 so that we could say that females do have a stronger implicit preference for natural products than males. However, it failed the significance test when conducting an Independent Two-sample t-Test ( $p=0.237>0.05$ ). Meanwhile, the sample number of study1(a) is not enough to make any conclusion on moderating effect, so we will discuss it later.

Since IAT is an inter-subject experiment, which studies the same subject's responses to two different aspects, so we used the paired Wilcoxon non-parametric test to judge the significant difference between the compatible and incompatible joint tasks. No matter in the group of practice tasks or formal tasks,  $p=0.000<0.001$ . In other words, individuals showed significant differences between incompatible and compatible conjoint tasks in both practice and formal stages, which again verified that the IAT experiment could measure subtle implicit attitudes and had an excellent evaluation performance. Therefore, our manipulation of model type was effective.

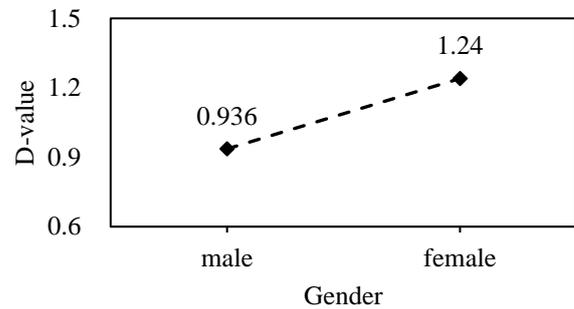
Generally speaking, in the current market, natural products are mostly daily necessities with low value (such as peanut oil and aloe gel, etc.), while non-natural products (such as computer and motor cars, etc.) are mostly high-value durable goods, which

means they do have an unavoidable difference in price and value. However, even in the same category, we couldn't control it with the same price. Take food as an example; organic food subordinated to natural products is often more expensive than ordinary food.



Source: This study.

Figure 3: Rural life experience difference in D-value in study1(a).



Source: This study.

Figure 4: Gender difference in D-value in study1(a).

Considering the unavoidable value difference in different categories, the concept words in study1(a) may affect the experimental performance of the subjects. So, we decided to conduct study1(b), using abstract product description adjectives to conduct the IAT experiment again for more rigorous exploration.

### STUDY1(B): EXAMINE WHETHER PREFERENCE FOR NATURAL PRODUCTS EXISTS

#### Measurement

In study1(a), we verified the existence of implicit natural products preference in different consumer categories successfully. Since the value of natural products and unnatural products is difficult to unify, which may influence the choice of subjects and reaction, we decided to use free association words as concept words, while other conditions remained the same.

#### Design and Procedure

Based on the study of natural product association words carried out by Rozin *et al.* (2012), study1(b) took two groups of words describing natural products and unnatural products as conceptual objects respectively to blur the specific product categories. The words were screened by three experts who are vice professors in college to avoid the bias of the material, as shown in Table 4. The choice of attribute words remained unchanged from study 1(a).

All procedures remained the same as study1(a). The only change was the concept words presented on the computer screen. Measures were the same as study 1(a).

#### Participants

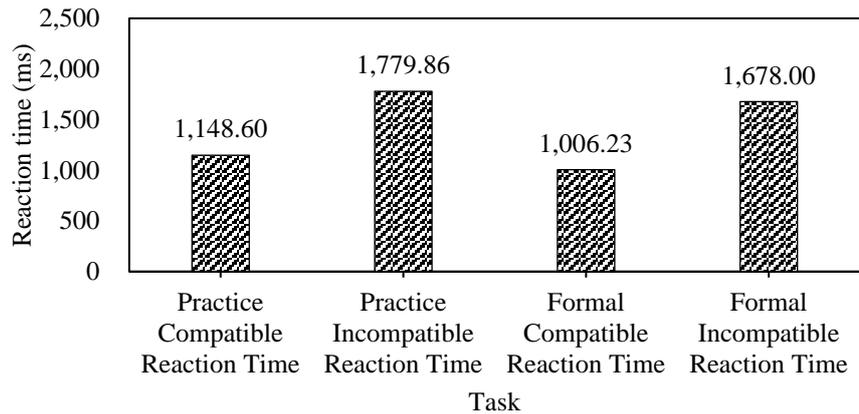
A total of 30 subjects participated in this experiment in Changsha, China. There were 14 male subjects and 16 female subjects, all of them aged from 18 to 25 years old, 96.7% of them were undergraduates, 17 subjects who had lived in urban areas for a longer time, and 13 subjects who had lived in rural areas for a longer time.

Table 4: Abstract Concept Words.

Natural products	Unnatural products
natural	technological
No-process	processed
No-additives	additives
Origin from nature	artificial

#### Result and Discussion

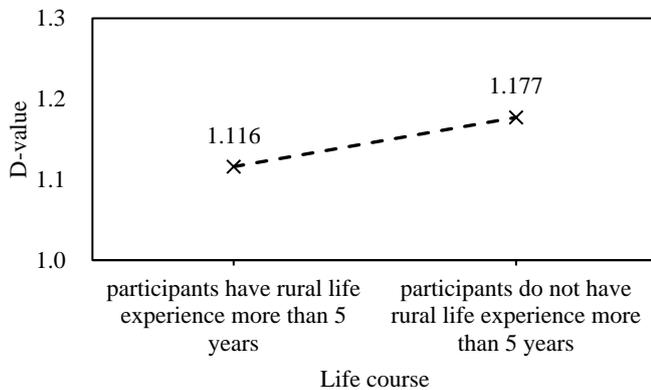
The data were processed in the same way as in study1(a). The average D value was 1.142, greater than 0.65, which verified the strong implicit natural product preference of the subjects again, supporting H1. So, when we don't consider the value difference between natural products and unnatural products, consumers still show a stronger preference for natural products. In study1(b), we can still infer the information from Figure 5 that participants need to spend more time associating natural products with negative words than unnatural products with negative words.



Source: This study.

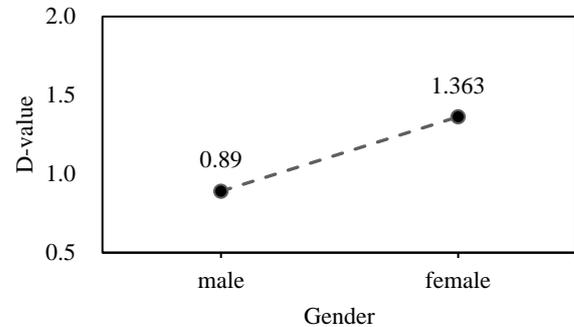
Figure 5: Reaction time in study1(b).

Any difference between rural life experience and gender is shown in Figure 6 & Figure 7. The result is similar to the conclusion in study1(a).



Source: This study.

Figure 6: Rural life experience difference in D-value in study1(b).



Source: This study.

Figure 7: Gender difference in D-value in study1(b).

The paired Wilcoxon non-parametric test showed the result of  $p=0.000 < 0.001$  when comparing the compatible and incompatible joint tasks, no matter in the group of practice tasks or formal tasks. Therefore, again, our manipulation of model type was effective in study1(b).

However, no matter in study1(a) or study1(b), the moderating effects could not be tested successfully. We first divided participants by whether they had lived in the countryside longer or not in each study and ran the Independent Two-sample t-Test. The result showed  $p=0.840 > 0.05$  in study1(a), and  $p=0.792 > 0.05$  in study1(b). Then we divided those participants by gender. The results also did not support our hypothesis, showing  $p=0.237 > 0.05$  in study1(a) and  $0.041 < 0.05$  in study1(b). Although the result of study1(b) seems to be significant, it could not be a convincing reason to support H3. Considering the IAT experiment only involved a small sample size, the main effects could be verified. However, the moderating effect should be verified in a greater sample size.

## STUDY2: EXPLORE THE MODERATING EFFECTS

### Measurement

We decided to use a situational experiment to measure consumers' preference for a specific classification of natural products, examining the moderating effects of rural life experience and gender. Meanwhile, we also examined different preference degrees when the categories differ in natural products.

### Design and Procedure

According to our definition of natural products, we decided to further refine products with natural ingredients and products that could raise the natural perception so that consumers can easily substitute them into the scene and make choices in accordance

with the real situation. With the help of experts who major in consumer behavior, we went out a discussion in a 10-people's focus group and finally selected vitamin C (chemical synthesis VC VS. Natural extracts VC), facial masks (hyaluronic acid facial mask vs. resurrection grass facial mask), vegetable shopping scenes (chain supermarket VS. small vegetable market) and single apartment (with urban landscape VS. with natural landscapes) these four situations as our experiment material. The experiment was presented online, and participants were asked to make a choice between the given options and score their willingness on a seven-point Likert scale. We also added related images to raise consumers' awareness towards four situations, making it more like in a real scene, so that the participants would make their real buying decision in a greater possibility. In order to avoid interference from other elements in the matching images, all images adopted in study 2 were processed with information occlusion.

### Participants

A total of 342 people participated in the online experiment. After filtering the ones who guessed out the real objective of the experiment, 301 valid data (effective rate 88.0%) were recorded. There were 175 men subjects and 126 female subjects. One hundred twenty-six of them had five years' rural life experience, while 175 of them did not have rural life for more than five years. There were 102(33.9%) subjects spending more time having rural life, and 199 respondents (66.1%) spent more time living in cities. The subjects were mainly aged from 18 to 24 years old (71.8%), and most of them were full-time students, including graduate and undergraduate (66.4%).

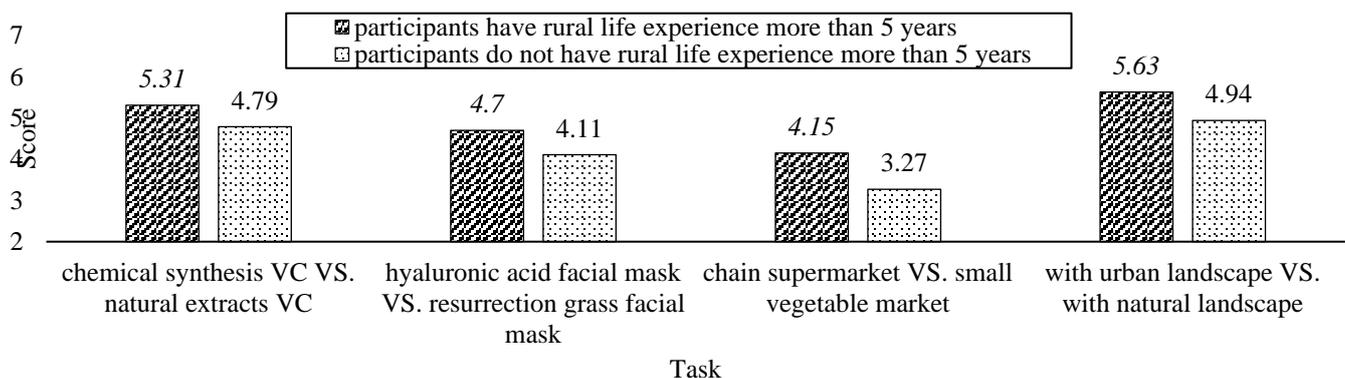
### Measures

All measures were answered on a seven-point Likert scale (1: I would definitely choose unnatural products to 7: I would definitely choose natural products).

In order to prevent the subjects, doping out the experiment's purpose and affecting data reliability, this experiment asked the subjects to write the purpose of the experiment in their mind at the end of the questionnaire. If the subjects made "investigation consumer preferences of natural products and unnatural products" or similar answer, the data needs to be manually deleted and excluded from valid data analysis.

### Result and Discussion

The results reveal that consumers prefer natural extracts vitamin C ( $M=5.09$ ,  $SD=0.12$ ), resurrection grass facial masks ( $M=4.46$ ,  $SD=0.11$ ), and single apartments with natural landscapes ( $M=5.34$ ,  $SD=0.12$ ). And they were significant in the Single Sample t-Test ( $p=0.000 < 0.001$ ,  $T=9.080$ ,  $4.108$ , and  $11.530$ , respectively). That is, compared with other products, consumers prefer natural products, supporting H1 again. In the scenario of vegetable shopping, both chain supermarkets and small vegetable markets were chosen by consumers, with an average of  $3.78(p=0.097 > 0.05, t=-1.666)$ . The result showed that the difference was not significant, but consumers, on the whole, prefer to buy vegetables in chain supermarkets. We proposed this may be caused by the urbanization process of consumption habits change. New guaranteed shopping chain supermarkets with a strong brand image, such as Fresh Hema and Aunt Qian, had won more consumers' trust and preferences.



Source: This study.

Figure 8: The average score of each group differs in rural life experience.

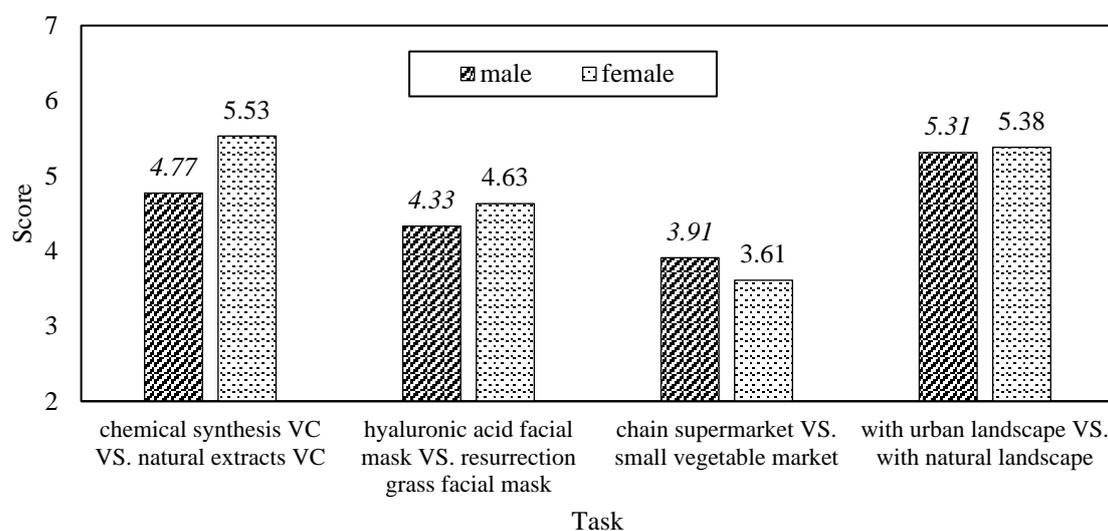
The difference is shown directly in Figure 8, suggesting that the participants who have rural life experience for more than five years score higher than those who don't, which represents the former have a stronger preference for natural products. According to the result, as for the subjects with more than five years of rural life experience, they preferred to buy vegetables in the small vegetable market, although this effect is not significant ( $p=0.358 > 0.05, t=0.921$ ). However, subjects without more than five years of rural life experience showed a significant preference for supermarkets,  $p=0.000 < 0.001, t=-3.726$ . It is also important to note that although in the overall single-sample analysis, for hyaluronic acid facial mask VS. resurrection grass facial mask,  $p=0.000 < 0.001$ , but in the Grouped Single Sample t-Test under the variable of 5-year rural life experience (Table 5), the subjects without 5-year rural life experience showed no significant product preference ( $p=0.527 > 0.05$ ). In comparison, subjects with more than 5-year rural life experience did show a significant preference for resurrection grass facial masks as natural products.

Table 5: Grouped Single Sample t-Test under the variable of 5-year rural life experience.

Whether participant has rural life experience more than 5 years		Test value=4					
		t	df	Sig (2 tailed)	Mean Dif.	95% Confidence Interval of the Difference	
						Lower	Upper
Yes	chemical synthesis VC VS. natural extracts VC	8.672	174	.000	1.309	1.01	1.61
	hyaluronic acid facial mask VS. resurrection grass facial mask	5.005	174	.000	.703	.43	.98
	chain supermarket VS. small vegetable market	.921	174	.358	.154	-.18	.48
	with urban landscape VS. with natural landscape	11.243	174	.000	1.629	1.34	1.91
No	chemical synthesis VC VS. natural extracts VC	4.069	125	.000	.786	.40	1.17
	hyaluronic acid facial mask VS. resurrection grass facial mask	.635	125	.527	.111	-.24	.46
	chain supermarket VS. small vegetable market	-3.726	125	.000	-.730	-1.12	-.34
	with urban landscape VS. with natural landscape	5.051	125	.000	.944	.57	1.31

Based on the above analysis, subjects without five years of rural life experience had more preferences to buy vegetables in the chain supermarket, but there is no significant preference for facial masks. For the subjects with five years of rural life experience, they prefer to purchase vegetables in the small vegetable market, although it was not significant. All in all, consumers did show a strong preference for natural products, a large part of  $p=0.000<0.001$ .

Similarly, we divided participants based on gender. The result shows that males and females both believe natural products are better when choosing vitamin C, facial masks, and a single apartment with a natural landscape ( $p<0.05$ ). But when it came to vegetable shopping, women scored lower than men. More of them chose to buy food in the supermarket (Figure 9 & Table 6).



Source: This study.

Figure 9: The average score of each group differs in gender.

### Hypotheses Testing

Then we processed the Independent Samples t-Test to examine moderating effects. Firstly, whether the subjects have more than five years of rural living experience been taken as a grouped variable, all results show  $p<0.05$  when they were choosing between buying natural products or not. That is, the results verified that whether the subjects have more than five years of rural living experience has a significant impact on the subjects' choice of natural products, supporting H2. Secondly, gender was used as a grouped variable, and it could be seen that the significance was only reflected in the product dimension of vitamin C ( $p=0.002<0.05$ ), while the  $p$ -values in other product dimensions were all greater than 0.05, indicating that gender had no significant impact on the subjects' choice of natural products. Thus, H3 was not supported.

Table 6: Grouped Single Sample t-Test under the variable of gender.

Gender	Test value=4
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		t	df	Sig (2 tailed)	Mean Dif.	95% Confidence Interval of the Difference	
						Lower	Upper
Male	chemical synthesis VC VS. natural extracts VC	4.536	174	.000	.771	.44	1.11
	hyaluronic acid facial mask VS. resurrection grass facial mask	2.189	174	.030	.326	.03	.62
	chain supermarket VS. small vegetable market	-.515	174	.607	-.091	-.44	.26
	with urban landscape VS. with natural landscape	8.321	174	.000	1.314	1.00	1.63
Female	chemical synthesis VC VS. natural extracts VC	9.896	125	.000	1.532	1.23	1.84
	hyaluronic acid facial mask VS. resurrection grass facial mask	3.855	125	.000	.635	.31	.96
	chain supermarket VS. small vegetable market	-2.077	125	.040	-.389	-.76	-.02
	with urban landscape VS. with natural landscape	8.048	125	.000	1.381	1.04	1.72

### CONCLUSION

To examine the preference for natural products, we first conducted 2 IAT experiments. Through each subject's reaction time in compatible and incompatible conjoint tasks, we calculated the D-value that suggests the IAT effect. The results were significantly greater than the reference value, verifying consumers do have a strong implicit preference for natural products. That is, consumers are more likely to connect natural products with fine words and quality, and they believe natural products are much more satisfying than unnatural products in their implicit attitudes, supporting H1.

Furthermore, we also conducted an online situational experiment to examine whether there are moderating factors affecting consumers' preference towards natural products. It turned out that gender would not make a significant difference when consumers are thinking about whether to choose natural products or not. Thus, H3 was not supported by our results. But there is one thing to mention that women do care more about whether the ingredients were extracted from nature in the food area, which was also verified before in Shin's research (Shin, J., & Mattila, A. S., 2019). In addition, when making choices between natural products and unnatural products, people who have lived a rural life for more than five years do think differently and act differently from those who lived in the city longer and merely don't have rural life experience. They significantly believed that natural products would be better in the given situations, which covers health care products, cosmetics, and the living environment, thus supporting H2.

Through analyzing the experimental data obtained from Study2, we found that consumers did not just have strong implicit preferences for natural products. They showed significant explicit natural product preferences as well.

### Theoretical Implication

The theoretical implications of this research are as follows. First, this paper expands our understanding of implicit association theory and life course theory in the field of natural preference and demonstrates the feasibility of using these two theories to explain consumer preference in this area. What's more, by analyzing the data collected from study1(a) & study1(b), the result from paired Wilcoxon non-parametric test did verify the effectiveness of IAT, which further demonstrates IAT's excellent accuracy of evaluating implicit attitude. Also, we featured on human capital by referring to life course theory and raised rural life experience as a moderating factor, which is also quite typical in China nowadays, since our lives have been affected hugely by urbanization for decades, and the urbanization process would also play a continuous and important role in the future. For a long time.

Second, our study also contributes to the literature on natural preference and natural products. Although there have been numerous studies on preference for organic food and natural landscape as subdivision topics, there has been little research on natural products as an integrated topic. This paper defines and classifies natural products, explores whether consumers have a consistent preference for overall natural products, and tries to answer the question that *Is Natural More Beautiful*.

### Managerial Implication

The managerial implications and suggestions of this study are twofold. First, it captures the consumption trend nowadays. In today's fast-paced life, more and more consumption phenomenon show consumer tends to pursue "natural product" consumption. For example, a travel agency that advocates ecology travel spots to relax and run away from anxious urban life would win a lot of support and admiration; a cosmetics company that advocates protection and prevention by extracting useful ingredients from nature would also make a profit. In this context, enterprises should pay attention to the practical needs of consumers, analyze the natural product categories that are more likely to be popular with consumers, and grasp the development and growth opportunities to explore the niche market. This study reveals the hidden layer in preference for natural products. Through a contextualization

questionnaire and the IAT experiments, we found out that, from the viewpoint of the life course, individuals with a continuous and longer time of rural life would have more preference for natural embrace due to “intimacy” and “nostalgia”; however, if individuals grow up in cities all the time, they would be more likely to choose technological and industrial “unnatural scenes” which were common in their past life.

Moreover, “homesickness” will also affect the purchasing decisions of consumers who have lived in rural areas in other shopping scenes. Therefore, enterprises can screen consumers' rural growth experience and geographical distribution to make an advantageous market strategy in segmented areas.

### Limitations and Future Research

Although our research has several limitations, these limitations represent opportunities for future research. First, the experiment materials we prepared (such as the concept words and the product information in the situation experiment) might not be the perfect substitute for a real situation. Also, differences remain between the preference presentation and the consumer's experience of real shopping. If future research could be conducted in real stores and if real consumers could be invited as participants in field experiments, the external validity of the research would be substantially improved.

In addition, we use rural life experience as a moderating variable, but in study2, we did not take full consideration whether the life experience would raise a non-linear effect. Instead, we only collected data on whether participants have rural life experience of more than 5 years or not by setting out a single-selected question. Is there a reversal effect in the results of more than ten consecutive years or 15 consecutive years of rural living experience? In other words, the relationship between the length of rural life experience and natural product preference still needs to be explored by future studies.

We also find it interesting that though gender might not raise significant influence towards consumers' preference for natural products, femininity might be a more proper variable, since Shin also mentioned that in her report (Shin, J., & Mattila, A. S. 2019). It would definitely be very interesting and meaningful to examine how these factors influence the effects of natural products preference.

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## Life-Cycle Building Carbon Emission Management Platform based on Building Information Modeling Technology

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### ABSTRACT

Buildings produce 40% of annual carbon emissions among various sectors in modern society. One of the most challenging problems of carbon management is how to monitor and calculate a building's life-cycle energy consumption and carbon emission data during both construction and operation stages. The Building Information Modeling (BIM) technology provides a promising method to obtain and simulate buildings as-is status at different stages in the life cycle. This paper develops a framework for building a carbon emission management platform using the carbon emission factor method and BIM technology, which can derive corresponding carbon emission and measure carbon footprint with building geographic information to achieve precise positioning of carbon emission objects. The platform can achieve multi-role collaboration, equipment visualization, real-time carbon emission monitoring, and data analysis. The platform is applied to an existing building in Hohai University to assess the total carbon footprint of the building in its life cycle. This platform can greatly improve the calculation accuracy of the carbon footprint of buildings, improve data transparency, provide valuable information for building facility management personnel, and help achieve the goal of carbon neutrality.

**Keywords:** Building Information Modeling, carbon footprint, life-cycle assessment.

### INTRODUCTION

As human activity produces more and more carbon emission, global warming is threatening human society and causing more and more problems. Many international organizations and governments of different countries have made a promise and plan to achieve the common goal of carbon neutrality. As one of the largest carbon contributors, buildings produce 40% of annual carbon emissions in the globe. Among the five stages of a building's life-cycle, i.e., design, construction, operation and maintenance, demolition, and recycling, the carbon emissions produced by the construction and operation maintenance stages account for about 90% of the carbon emissions of the whole life cycle. This means that improving the carbon footprint management of the public building and operation and maintenance stage, controlling the carbon emissions of the construction and operation and maintenance stage is very important to reduce the total carbon emissions and promote the upgrading of the energy structure system in the construction industry. For construction managers and building facility managers, carbon management is difficult to implement due to a lack of information and data about a building's carbon footprint data, especially for existing buildings. The building carbon footprint management platform, which can achieve accurate calculation of the carbon footprint, carbon data monitoring, and analysis, is in great need for building facility management.

With the advantages of integrating building information from various sources, BIM has the potential to play a key role in carbon reduction control in the construction, operation, and maintenance stages. In the construction stage, BIM acts as an information integration platform to evaluate and simulate carbon emissions on the network, assist in prefabricated construction without building physical facilities, also greatly reduce carbon emission (Hao *et al.*, 2020). In the stage of construction operation and maintenance, a green transformation has become a new development trend and sustainable evaluation using BIM

(Lim *et al.*, 2021). is mainly realized through data management to provide the building information required for performance simulation, real-time modification of the model using analytical feedback, and compatibility with performance simulation software. However, due to the practical difficulties of evaluation standard establishment, data acquisition, automation management, and interactive design, the practical application of BIM in building carbon reduction are rare. The current life-cycle assessment (LCA) approach has been considered feasible for potential theoretical guidance, and the current study has found that LCA combined with BIM has the potential to reduce the difficulty of classification and collection of carbon emission data. During the whole life-cycle of a construction project, uncontrollable factors such as construction period limit, environmental change, technical iteration, and material replacement all add difficulties to the practice of LCA, and the combination of BIM and LCA is expected to improve this situation (Yang *et al.*, 2018). Moreover, carbon emission control and sustainable design in the existing building operation and maintenance stage urgently need to clarify the BIM workflow, but the lack of practice leads to the lack of high precision of the existing building BIM models and data, such as spatial data inside the building, operation data of energy consumption, and many others (Lim *et al.*, 2021). To sum up, BIM technology is widely used in the construction and operation maintenance stage of low-carbon building research, but it still needs to improve the accuracy of carbon footprint calculation methods, optimize the working framework to be compatible with different simulation tools, and improve the level of automation to complex situations.

## LITERATURE REVIEW

### Research on Carbon Emission Related During the Construction Stage

At present, the following three methods are widely accepted in carbon footprint calculation. The first is the carbon emission factor method. Since the traditional inventory analysis method is more widely applied in the mature construction drawing design stage or with a detailed bill of quantities, this method is suitable for measuring carbon emissions in the design stage or after the end of the project. For example, the CO<sub>2</sub> emission due to the building materials consumption can be calculated by the data China Statistical Yearbook on Construction combined with the known carbon emission factors (Zhang & Wang, 2016). The Korea Life Cycle Inventory Database can be used to assess the carbon emissions for each material used in the project for a building complex combined with electric carbon emission factors (Seo *et al.*, 2016).

The second method is the method of Life Cycle Assessment (LCA) combined with carbon emission factors. The LCA is a method of assessing the environmental impact of products during their life cycle (Cang *et al.*, 2020). Currently, there are three carbon emissions calculation methods for building life cycle assessment (LCA), i.e., process-based LCA (P-LCA), input-output LCA (I-O-LCA), and hybrid LCA (H-LCA). Each method has its own characteristics and scope of application. Such methods as can be used to assess the environmental impact of buildings during the entire life cycle. They are often combined with carbon emission factors for the systematic measurement of building carbon emissions. The combined LCA approach and carbon emission factors are used to assess and compare emissions in different climates from different building and structural buildings (Luo & Chen, 2020).

The third method is the method using BIM combined with carbon emission factors. With BIM technology developing, it became possible to get building information model early in the design stage. BIM emerged as a solution, allowing one to measure real-time carbon emissions in the materialized phase. Bentley's Open Building Designer software is one of the tools to implement BIM technology. In the software, the engineering view can be presented in 2D and 3D views, and BIM software can export quantities data at any time node based on the project schedule plan. Based on the derived quantities data and combined with the known carbon emission factors, the carbon emission measurement in the materialization stage can be carried out with a simpler and more widely applicable method. Carbon emission measurement in the construction phase using BIM technology combined with carbon emission factors helps users save time and effort for the subsequent carbon reduction optimization design. Based on the above discussion, this paper uses BIM technology combined with the existing carbon emission factors to achieve real-time measurement of carbon emissions in the construction phase.

Table 1: Analysis of carbon emission calculation method in building chemical stage.

Methods	Advantages	Limitations	Applicable object	Application status
Carbon emission factor method	1. It is simple to calculate with high credibility; 2. Have a specific carbon emission factor database available; 3. Very wide application and mature system	The calculation results are rough, and the carbon emission factors of different statistical sources are quite different, and there is a gap from the standardized quantitative calculation	It is applicable to a national strategic level, and calculation of social and economic carbon emission sources are relatively stable	Widely used, high recognition, conclusion authority

LCA+ carbon emission factor method	Detailed calculation results can be given for specific assessed objects	Combining process analysis and input-output analysis produces multiple calculations; It needs more time and data; drawbacks in system boundary determination and data collection	It is applicable to government environmental decision-making management, economic evaluation, and social evaluation	Widely applied with credible conclusions
BIM + carbon emission factor method	<ol style="list-style-type: none"> <li>1. The results are accurate, and building energy consumption data can be obtained directly</li> <li>2. The method can be combined with carbon emission factors from different regions</li> <li>3. Achieve the standardized quantitative calculation</li> </ol>	BIM-related software is not mature. The building material carbon data are not accurate	Suitable for the carbon emission management of large public buildings or architectural complexes	No mature application in the building preliminary virtual simulation stage

### Research on Carbon Emission Related in the Construction Operation and Maintenance Phase

There are three main methods for calculating carbon emissions in operation and maintenance stage. The first one is the emission factor method, which is widely used. Its basic idea is to construct the activity data and emission factors for each emission source according to the carbon emission list, and then take the product of the activity data and emission factor as the carbon emission estimation value of the emission project (Köne & Büke, 2019). In this method, the activity data is mainly derived from relevant national or regional survey data. The emission factors can use the reference value given by the global average level in the IPCC report (Eggleston *et al.*, 2006).

The second method is the quality balance method (Guo & Ma, 2019), which considers the direct emissions, indirect emissions, and the final generated carbon sink, that is, considering the full input and output to follow the law of quality conservation as the basic principle. This method is a quantitative analysis of the energy consumption and CO<sub>2</sub> emissions generated in the whole process.

The third method is the energy measurement method, which is based on the basic data of the field energy measurement in the construction operation and maintenance stage to collect the relevant carbon emissions. In the building energy consumption measurement work, the concept of classification should be adopted to measure various energy consumption such as air conditioning, electrical light, water, and power consumption.

Based on the above-related methods and literature review, this paper proposes the BIM + carbon emission factor calculation method, based on the BIM model and monitoring data, to transfer building-related energy consumption data to the background to summarize the relevant carbon emissions. This method can organically combine energy measurement method with computer internet of things technology and the application of carbon emission factor method.

Table 2: Analysis of the carbon emission calculation method in the construction operation and maintenance phase.

Methods	Advantages	Limitations	Applicable object	Application status
Carbon emission factor method	<ol style="list-style-type: none"> <li>1. Simple to calculate with high credibility;</li> <li>2. Specific carbon emission factor databases are available</li> <li>3. Widely used application and mature system</li> </ol>	The calculation results are rough, and the carbon emission factors of different statistical sources are quite different, and there is a gap from the standardized quantitative calculation	In the calculation of carbon emissions at the national strategic level, the social and economic carbon emission sources are relatively stable, ignoring their internal complexity	<ol style="list-style-type: none"> <li>1. It is widely used</li> <li>2. High recognition</li> <li>3. Conclusion authority</li> </ol>
Quality balance method	Clarify the relationship between various kinds of equipment and natural emission sources	Data acquisition is difficult. The method is not standardized. The data lack authority is not suitable for a single building	Social and economic development develops rapidly, and building carbon emission equipment is updated rapidly	<ol style="list-style-type: none"> <li>1. No standardized measures were available</li> <li>2. The conclusions are not universally accepted</li> </ol>
Energy measurement method	The measurements are very accurate	Data is difficult to obtain, and it is difficult to investigate building carbon emissions at the overall social level.	Single building measurement, suitable for buildings with access to energy data	<ol style="list-style-type: none"> <li>1. Difficult in obtaining data;</li> <li>2. The scope of application is too narrow</li> </ol>

<p>BIM+ carbon emission factor calculation method</p>	<p>1. The results are accurate, improve the deficiency of energy measurement method, and directly obtain construction energy consumption data                  2. Building structural factors were selected from the relevant carbon emission factor database                  3. Realize the standardized quantitative calculation</p>	<p>The precise grasp of the results, this plan is limited to the analysis of carbon emissions in the operation and maintenance stage of single buildings and fails to realize the carbon emission analysis and survey of the whole city and even the whole society</p>	<p>Single large public building measurements</p>	<p>No universal application in the building preliminary virtual simulation stage</p>
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**RESEARCH METHODOLOGY**

For the calculation and monitoring of building in the entire life-cycle, a BIM-based collaborative management platform is designed to assist the units involved in carbon emission control and provide corresponding suggestions. Starting from the two stages of building materialization and operation and maintenance, the platform conducts the overall design with three basic functions: multi-role collaborative participation, real-time monitoring of carbon emissions, and visualization of existing facilities.

**Platform Design Ideas**

According to the actual practical requirements of public building carbon reduction in the construction field, three basic functions are designed, namely real-time monitoring of energy consumption, equipment visualization, and multi-role collaborative participation.

The first is to have the building's energy consumption monitored in a timely manner, which is mainly used in the operation and maintenance stage. Carbon emissions in operation and maintenance phase are mainly concentrated in energy consumption. Compared with the construction phase, the operation and maintenance phase does not have a very clear monitoring facility for energy consumption. In order to solve this problem, infrared sensors, power sensors, water flow sensors, remote control facilities, and RFID devices are embedded in each monitoring target in advance. After energy consumption data such as electricity and water consumption are obtained, and energy consumption data of equipment can be analyzed timely by integrated application of BIM and Internet of Things, and finally, BIM cloud database in operation and maintenance stage can be constructed. Based on the database, we designed the data processing function of the platform system. In order to obtain the carbon emissions, after the energy consumption database is obtained, the BIM+ cloud computing technology is used to process the energy consumption data in the database according to the pre-set calculation formula of carbon emissions. The BIM cloud carbon emission database at the operation and maintenance stage is obtained by integrating carbon emission data.

Then, visualize the device situation. After loading the sensor and obtaining the BIM cloud carbon emission database at the operation and maintenance stage, we encountered the problem that the obtained database information could not be transmitted synchronously to the BIM collaborative management platform system. To this end, this paper uses Navicat database software and its built-in data synchronization function to synchronize the BIM cloud carbon emission database information to Navicat database and then build a link between Navicat and the cloud server where the BIM collaborative management platform resides. At this point, the platform can extract the carbon emissions of the monitoring targets stored in the Navicat database and present them simultaneously on the platform management interface.

The third technical difficulty is multi-user collaborative participation. BIM technology is used to import the BIM model of the building into the platform and back it up to the cloud. With this model as a node, multiple users can be linked so that they can view the BIM model at the same time, and different projects, work details, and corresponding data can also appear in the platform interface. After the modification and saving of the corresponding data, the modification record is synchronized to the platform system interface of the decision-maker to realize the timely update of the data. After solving the above four technical keys, the platform realizes the three basic functions of this BIM-based collaborative management platform. The overall framework of the platform is shown in Figure1.

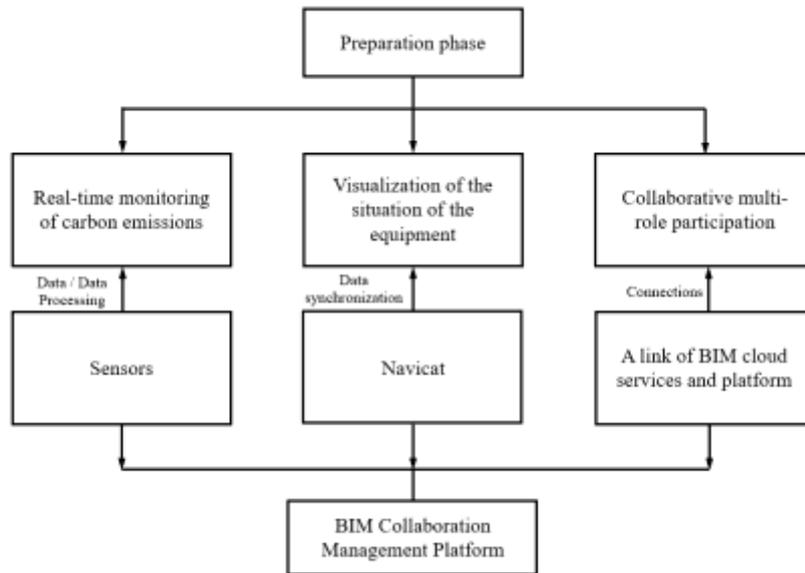


Figure 1: Research methodology.

**Calculation Methods for Materialization and Operation and Maintenance Stage**

**Materialization stage**

The calculation of carbon emissions in the production stage of materials refers to the calculation of carbon emissions produced by the mining production of raw materials and the transportation of building materials. Based on the basis of the consumption of all types of raw materials in the system analysis stage, the material consumption can be converted into carbon emissions through the emission coefficient method to obtain the total carbon emissions produced in each stage of the material production stage. After investigation and research, the indirect emission generated by the construction electricity and equipment electricity during the construction process is the largest emission source in the construction activities. Therefore, the electricity consumption during the materialized stage can be measured by the power carbon emission factor.

Table 3: Source of carbon emissions in the materialized stage.

The materialized stage	Carbon emissions sources
Material production stage	Carbon emission of raw materials and production of building materials
Construction stage	Carbon emissions from construction machinery operation during the construction period and carbon emissions from site processing of + materials

(1) Calculation model of carbon emission in the material production stage

The carbon emission calculation model (Eq. 1) in the material production stage is constructed as follows:

$$C = C_1 + C_2 \tag{1}$$

Type in: C: carbon emission in the building chemical stage;

C<sub>1</sub>: Carbon emissions in the building materials mining and production stage;

C<sub>2</sub>: Carbon emissions in the building materials transportation stage;

Carbon emission calculation formula (Eq. 2) is:

$$C_1 = \sum Q_i \times F_i \times (1-s) \tag{2}$$

Type: C<sub>1</sub>: Carbon emissions in the building materials mining and production stage;

Q<sub>i</sub>: Type I building materials requirements for the cast-in-place project;

F<sub>i</sub>: Type I th carbon emission factor of building materials;

s: The recovery coefficient of class i building materials.

For all kinds of building materials and equipment, the carbon emission factors of building materials have been given in the Building Carbon Emission Calculation Standard released by China in 2019.

The carbon emission calculation formula (Eq. 3) of the building materials transportation stage is:

$$C_2 = \sum Q_i \times L_i \times T_i \tag{3}$$

Type: C<sub>2</sub>: Carbon emissions in the building materials transportation stage;

Q<sub>i</sub>: Demand for type I building materials for cast-in-situ engineering;

L<sub>i</sub>: Average transportation distance of type i building materials;

T<sub>i</sub>: The carbon emission factor of transportation distance per unit weight for the transportation mode of type i building materials.

The acquisition method of demand for building materials in the formula is roughly the same as that of  $Q_i$  in the previous formula. It can be obtained through the purchase list and other materials, and the transportation distance of building materials can be obtained through the freight list and other materials. Carbon emission factors of various modes of transportation can be learned through consulting the Construction Carbon Emission Calculation Standards.

(2) The calculation of the carbon emission model in the construction stage

This model is proposed to adopt direct measurement, calculating the synchronous carbon emissions of various equipment during construction by directly monitoring the power consumption during construction. The synchronous monitoring model of carbon emission (Eq. 4) during the construction stage is constructed as follows:

$$P_d = E \times E_e \quad (4)$$

Type: E: power consumption (kw · h)

$E_e$ : Electric Power Carbon Emission Factor (t/kw · h)

Power carbon emission factors can be obtained by consulting the construction carbon emission factor database (Song *et al.*, 2013).

### **Operation and maintenance stage**

In the operation and maintenance stage, the carbon emission factor-based emission coefficient method is adopted as the carbon emission calculation method, and the basic principle can be expressed as "carbon emission = activity data × carbon emission factor." This system studies the carbon emissions in the process of construction operation and maintenance. The activity data used are mainly energy usage, and the carbon emission factors used are mainly energy carbon emission factors.

Table 4: Source of some energy carbon emission factor database.

International organizations	Data sources
Intergovernmental Panel on Climate Change (IPCC)	IPCC Guidelines for National Greenhouse Gas Inventories Emission Factors Database, EFDB
International Energy Agency (IEA)	CO <sub>2</sub> Emissions from Fuel Combustion database (International Energy Agency, 2013) IEA GHC CO <sub>2</sub> Emissions Database (Greenhouse Gas Protocol, n. d.)
World Resources Institute (WRI)	GHG Protocol Tool for Energy Consumption in China (Song & Yang, 2011)
Energy Information Administration, US Department of Energy (DOE/IEA)	Voluntary Reporting of Greenhouse Gases Program (Van der Heijden, 2018)

### **WORKFLOW DESIGN**

In the materialization stage, in order to achieve the carbon emission measurement of the project, the construction quantity table needs to be exported. With the help of Bentley OpenBuilding Designer software, the construction quantity of the project at different time nodes can be exported in the form of Excel form according to the schedule of the project. Upload the quantities to the management platform, which can calculate the total carbon emissions of the project at this time node according to the embedded formula.

To upload the exported construction quantity data to the platform for analysis and calculation, Navicat database software is used in this project, and its built-in data synchronization function can synchronize the construction quantity data to the Navicat database. Navicat software is used to build a link with the cloud server where the carbon emission management platform is located, and the platform can extract the project quantity data stored in the Navicat database to calculate the carbon emission.

Using BIM+ cloud computing technology, the platform matches the data in the database with the corresponding computing model and processes it according to the pre-set carbon emission computing formula. Cloud computing technology can transfer the complex carbon emission computing work in BIM to the cloud to improve computing efficiency. With the help of the building collaborative management platform, the carbon emission data can be fed back to the users in real-time. And the interconnection between various terminal devices can be realized by using cloud computing technology. Users connect the cloud service via a computer or mobile to view the carbon emissions during the materialized phase. The materialized phase process is shown below in Figure 2.

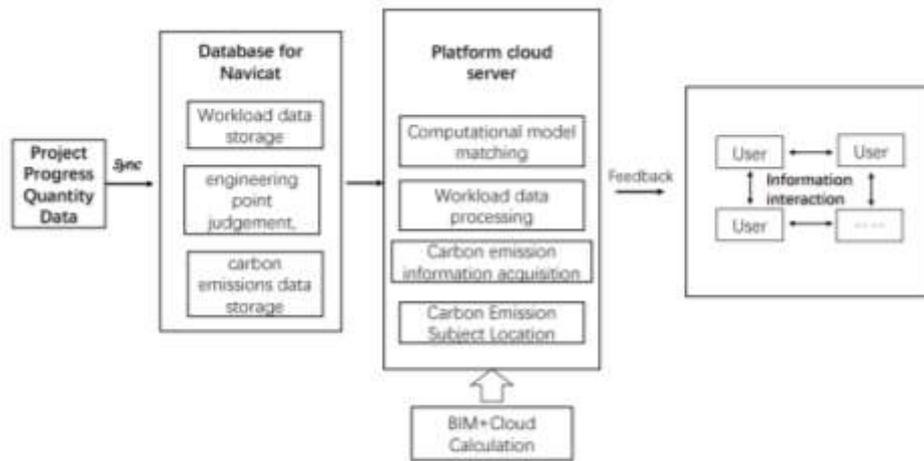


Figure 2: The process of the materialization stage.

As shown in Figure 3, in the operation and maintenance stage, remote control facilities and equipment such as infrared sensors, water flow sensors, and power sensors, and RADIO frequency identification devices are embedded in the monitoring target in advance. By relying on BIM+ Internet of Things technology, the power consumption and key operating parameters of the equipment are integrated into the building collaborative management platform, and data interconnection network and database are established. BIM+ cloud computing technology processes the energy consumption data in the database and feeds the carbon emission data to users in real-time through the platform interface, which can realize the interconnection between various terminal devices and facilitate users to view the carbon emission information of buildings in operation and maintenance stage. BIM +GIS technology is used to collect, store, manage, calculate, analyze, display, and describe geographic location distribution data in space, integrate geographic information into the platform, and combine with the spatial information in the model and the surrounding geographical environment, which clearly reflects the specific location of energy consumption equipment in the system. According to the *Energy Consumption Standard for Civil Buildings* issued by the Ministry of Housing and Construction in China, the platform can hold responsible persons of energy consumption equipment with excessive carbon emissions accountable in real-time. Based on this technology, the platform can accurately locate the machines with excessive carbon emissions, conduct a timely inspection, and analyze the equipment and its operation. The platform will then adopt the most energy-efficient way to control carbon emissions based on the carbon reduction database.

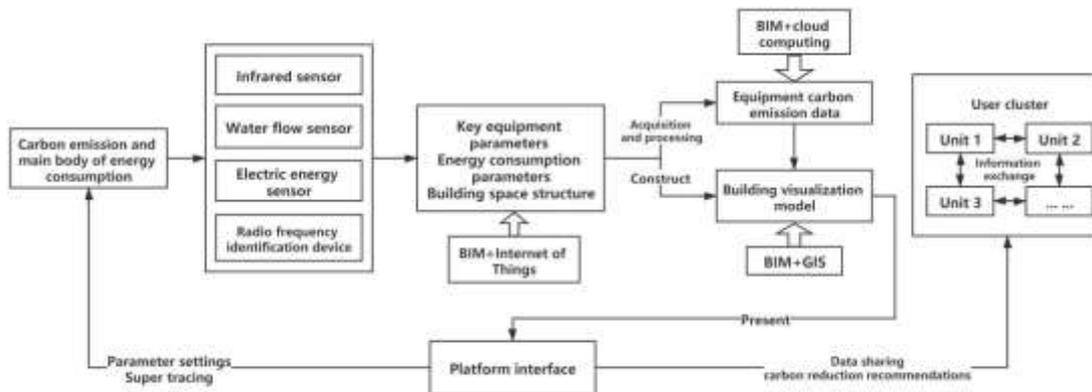


Figure 3: System operation process in the operation and maintenance stage.

The platform presents the corresponding content according to the user's permission. For non-management personnel in the building operation and maintenance stage, the interface only displays real-time building carbon emissions; for managers in the building operation and maintenance stage, the interface not only displays real-time carbon emissions of buildings but also positions equipment with excessive carbon emissions and energy consumption and provides relevant carbon reduction suggestions to control carbon emissions. In addition, the platform can undertake simple logical deduction and realize the simplification, intelligence, and humanization of operation and maintenance management. The framework chart of the platform is shown in Figure 4.

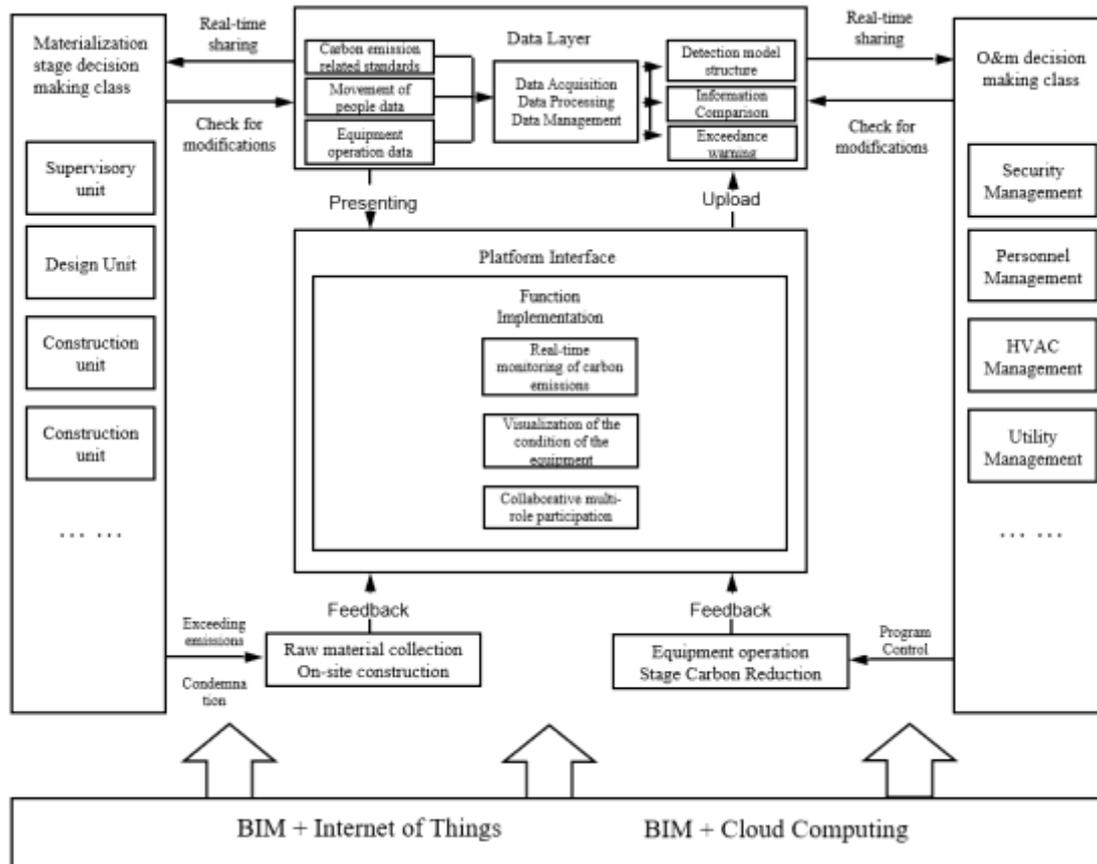


Figure 4: Platform framework.

**FUNCTIONAL IMPLEMENTATION**

First, multi-role collaborative participation. The BIM-based collaborative management platform shares internal data within the building, allowing departments to view it simultaneously. At the same time, the relevant data authority is authorized according to the professional and subordinate departments, and each professional department can only adjust or use part of the content, ensuring the coordination and management of each department and performing its own duties.

Secondly, real-time monitoring of carbon emissions. The front-end facility captures the carbon emission dynamic data in real-time and uploads it to the data layer at fixed points for processing. When the data is beyond the scope or becomes abnormal, activate the built-in alarm mechanism immediately to provide detailed alarm information and remind the responsible department. The platform regularly evaluates the construction safety and equipment safety during the operation and maintenance stage and carries out emergency management.

Thirdly, visualization of the existing facilities. The management center interface shows the internal spatial structure of the building and the real-time trend chart of carbon emissions of various departments. After the user layer makes the corresponding instructions to the application layer, the changes of the relevant equipment will also be immediately displayed on the interface. The data processing center supports the integration of the user's multiple instructions into a phase carbon reduction scheme and storage. When the user uses the scheme, the interface displays its past usage of it.

Fourthly, the intuitive embodiment of the BIM model. The platform is closely combined with the BIM model, viewing the content of the BIM model at any time when entering building information or performing other operations on this platform. Only need to enter the website of the platform server in the browser, enter the account, log into the building collaborative management platform, click the "building information" in the new project, the BIM model and data content can be seen. Among them, the platform subdirectory system is on the left, and the right is the data display and model operation interface. The operation interface is shown in Figure 5.

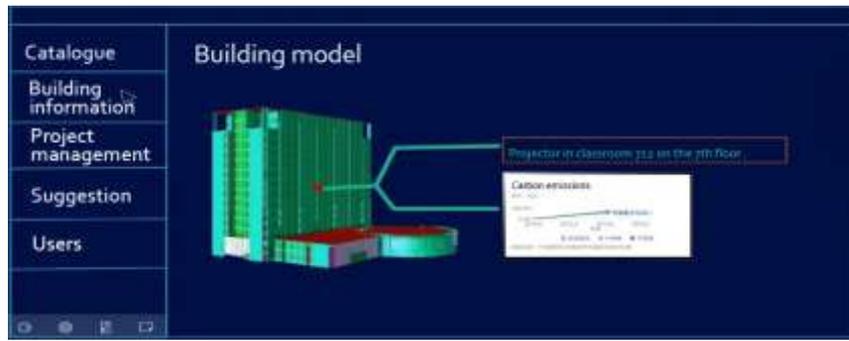


Figure 5: Operating interface diagram.

In addition, we find that the content and form of carbon emission data of public buildings have obvious dynamic characteristics. In order to better help users improve the efficiency of carbon emission reduction, it is necessary to adopt centralized management for dynamic data and configure relevant services centered on the data source (Ju & Chen, 2015). Therefore, in the operation and maintenance stage, the platform has established a carbon reduction measures database and extracted, integrated, and correlated the data sources according to the industry classification and external conditions so as to establish a carbon reduction measures retrieval directory according to the principle of source consistency (Shi *et al.*, 2014). While ensuring the reliability of the information, it also meets the specific needs of different users under different conditions. Users can accurately search for carbon emission reduction measures according to corresponding external conditions and their own needs and realize information interaction with other users at the same time.

After sending the search command, the information is transmitted from the user layer to the data layer. The platform will automatically identify and transform the key data in the search command, form the search conditions, and locate it in the directory according to the conditions. Then, the retrieval results and corresponding carbon emission change values are exported from the Navicat database, and the two are combined into a data group for text display. It should be noted that the work experience and expert evaluation on carbon emission management in the construction operation and maintenance stage within three years will be included in the display results.

Users can view and select the search results. After the selection instruction is issued, the selected text is recognized, split, and reorganized by the data layer, and the application layer is contacted in the format of "equipment information + used power + running time period" to set one or more corresponding devices with one key. The above operations will be included in the carbon reduction measures library.

The processing rules of carbon emission data and carbon reduction operation data in the operation and maintenance stage are shown in Table 5 below.

Table 5: Data processing rules in the operation and maintenance stage.

Type	Data structure	Function
Search command	Retrieval time + user's unit + external conditions + carbon emission change value	Retrieving user commands
Search Results	Usage times + service time + historical operation + carbon emission of equipment + expert evaluation	Rendering search results
Application Commands	Number of devices + location of devices + Power of devices + Running time + Whether manual intervention can be performed	Managing device operation

### PROJECT APPLICATION

The research of this project is applied to Boxue Buildings of Hohai University Jiangning Campus, which has one 15-story main building and one 5-story auxiliary building, with a total construction area of 37,544 square meters. The construction of the building structure started in 2008 and ended around July 2009. The civil works ended in December 2009 and were put into use after local decoration in 2010. The appearance of the Boxue Building is shown in Figure 6.



Figure 6: Full picture of Boxue Building.

### BIM Modeling, Simulation, and Analysis

According to the BIM model of the main building and auxiliary building of Erudite Building, it is estimated that the average construction needs about 407 tons of concrete. According to the literature, for the same type of similar size buildings, the transport pump unit volume of concrete electricity consumption is 2.97 kWh/m<sup>3</sup>. The average daily electricity consumption of the main structure construction stage is 68.4 kWh per day, and the average electricity consumption of the decoration construction stage is 44.3 kWh per day. According to the data, the average carbon dioxide emission factor of the Jiangsu Province power grid is 79,400 t/kWh. Carbon emission data can be estimated for the construction phase of Boxue Building.



Figure 7: Construction progress and BIM model simulation of the main building.

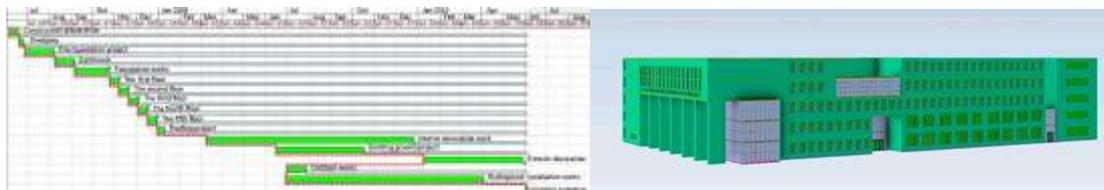


Figure 8: Construction progress and BIM model simulation of the auxiliary building.

In the example, the previous five floors conducted a detailed analysis. In order to achieve the estimation of the carbon emission in the materialized stage, only the amount of concrete and steel quantity derived in the current BIM model was studied, and the analogy method was adopted to calculate the power consumption data of the same type of construction devices of buildings with similar construction area.

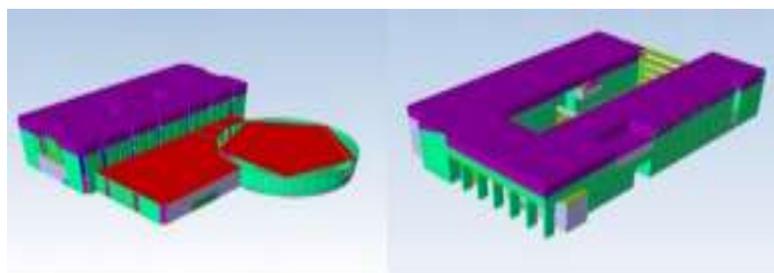


Figure 9: BIM construction progress simulation of Boxue building.

(Note: The left figure shows the construction of the main building on December 23, 2008. The right figure shows the construction progress of the auxiliary building on January 7, 2009.)

The construction quantity of Boxue Building is derived from Bentley software, and it can be concluded that 3376 m<sup>3</sup> of concrete and 501 tons of steel are used in the construction of the main building to the fifth floor. When the auxiliary building was built to the fifth floor, it used 9975 m<sup>3</sup> of concrete and 1482 tons of steel. Referring to the Building Carbon Emission Calculation Standard, the carbon emission factor of C30 concrete is 295kg/m<sup>3</sup>, hot-rolled carbon steel reinforcement is 2340

kg/t. It can be calculated that during the material production phase, Boxue Building produced 2168.26 t CO<sub>2</sub> on the 5th floor of the main building and the auxiliary building produced 6410.505 t CO<sub>2</sub>. For the construction stage, similar construction projects can reach the average daily power consumption of 68.4 kWh/day in the main construction stage, calculate the total electricity consumption of the main building and auxiliary building to the fifth floor is 8994.6 kWh. The power carbon emission factor in Jiangsu Province is 793 t/10000kWh. In conclusion, for Boxue Building, the total carbon emission in the construction phase is 8585.90 tons of carbon dioxide as calculated by carbon emission factor and analogy analysis.

**Carbon Emission Analysis of the Project Operation and Maintenance Phase**  
*System interface diagram in operation and maintenance phase*

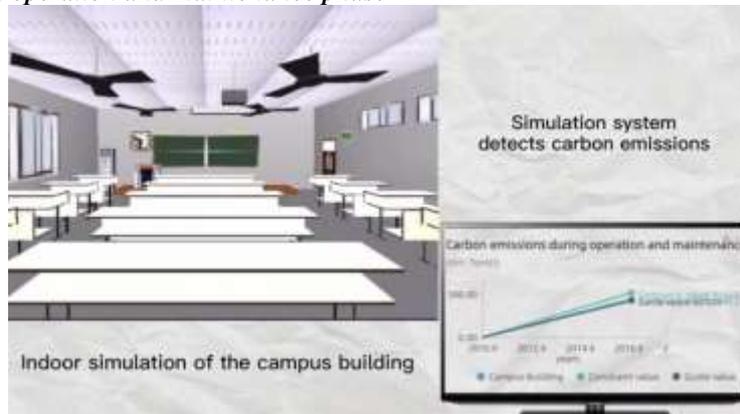


Figure 10: System display interface diagram in operation and maintenance stage.

**The carbon emission data calculation in operation and maintenance stage**

The constraint values and guide values in Table 6 refer to the relevant indicators of non-heating energy consumption of commercial office buildings in hot summer and cold winter areas in the Energy Consumption Standard for Civil Buildings. Erudite Building maintenance stage carbon emissions mainly come from HVAC, lighting, air conditioning, projection, and elevator equipment, the use of this equipment is directly related to the building personnel flow and climate change, equipment related energy consumption data from building collaborative management platform, through the platform internal automatic data acquisition, data processing, data accountability final feedback to the platform display page, for a cycle export the cumulative carbon emissions of the campus building, the maintenance stage carbon emissions database.

Table 6: Carbon emission calculation data during the campus construction operation and maintenance stage.

Cumulative carbon emissions (ton) / Time	Campus building	Constraints	Guide value	Note
2010.6	0	0	0	
2011.6	72.155	85	70	
2012.6	144.309	170	140	
2013.6	216.464	255	210	
2014.6	288.619	340	280	
2015.6	360.773	425	350	
2016.6	432.928	510	420	
2017.6	505.083	595	490	
2018.6	577.237	680	560	
2019.6	649.362	765	630	
2020.6	685.440	850	700	Due to COVID-19
2021.6	757.595	935	770	

**CONCLUSIONS**

Evaluating carbon emissions for public buildings during life-cycle stages is of great importance under the context of global carbon neutrality. With advanced information integration ability and 3D interactive visualizing function, the proposed method in this paper can improve the carbon emission calculation accuracy for existing buildings using its BIM model and real-time monitoring data. It can significantly reduce the cost of carbon footprint tracking and carbon emission data management, improve information accuracy and promote low-carbon buildings. The BIM-based carbon emission collaborative management platform proposed in this paper uses advanced information technology to provide a one-station solution for building owners and facility managers to have a better understanding about the carbon emission and provide evidence to make better solutions to achieve zero-carbon buildings.

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## Motivations of User Engagement in eWOM of Chinese Microblog

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### ABSTRACT

This study examined the motivations of user engagement in electronic word-of-mouth behavior through a netnography. The sample includes more than 2,000 posts from the Chinese microblog-Sina Weibo and 20 follow-up interviews about film reviews. 5 types of motivations were examined, including egoistic motivations, motivations for the reward, reciprocal motivations, altruistic motivations, and motivations in the sense of community. Results confirmed the effect of egoistic motivations, reciprocal motivations, and motivations in the sense of community for the increasing volume of eWOM. However, motivations for the reward and altruistic motivations were found less powerful. Hence, the reward was found to decrease the generation of eWOM. The findings would give implications for marketers to plan and leverage eWOM and help scholars understand eWOM in a microblog context.

*Keywords:* Motivations, eWOM, microblog, virtual community, netnography.

### INTRODUCTION

The development of the internet is changing the environment of the virtual community and making the interaction between peer members more important than before (Kozinets *et al.*, 2010). A better understanding of the motivation for members to engage in eWOM of films is needed. Recently, microblog gathering a wide range of users from society has become an important social media platform for consumers to generate eWOM (Yoon *et al.*, 2017). Booming microblog users made microblog sites a primary source of news in China. The eWOM on microblogs is urgent to be studied for helping understand the culture in the new form of virtual community (Hennig-Thurau *et al.*, 2015) .

Superior research has adequately verified the effects of eWOM on purchase decision-making and attitude change (Duan *et al.*, 2008). However, the other important aspect of eWOM -the generation of eWOM still lacks investigation (Liu *et al.*, 2017). For filling the gap in the literature, the study aims to explore the motivations of microblog users' engagement in eWOM of films on Chinese microblog—Sina Weibo.

We proposed 5 specific motivations and tested them in a netnographic research, including egoistic motivations, motivations for the reward, reciprocal motivations, altruistic motivations, and motivations in the sense of community. Online observation and online interviews were used as tools for this qualitative research.

### LITERATURE REVIEW

This chapter begins by reviewing the development of eWOM theory and identifies the powerful effect of eWOM. It continues with the literature on virtual communities and motivations for engaging eWOM. It then reviews the eWOM in the specific context: the film industry, which is also the environment of the research. The gaps in the literature review will be included and considered as the guidance for the present study.

### eWOM

Traditional word-of-mouth (WOM) was originally defined as an oral form of interpersonal commercial communication among acquaintances (Cheung & Lee, 2012). With the popularization of the internet, numerous venues provided for consumers to share their views and experiences, translating traditional WOM into a new form of communication, namely electronic word-of-mouth (eWOM) communication. (Hennig-Thurau *et al.*, 2004) defined eWOM as “any positive or negative statement made by potential, actual, or former customers about a product or company, which is made available to a multitude of people and institutions via the Internet”. He suggested that knowledge on traditional WOM communication in the literature can also be used in the online setting.

The effect of eWOM was empowered with the advent of the Internet (M. Lee & Youn, 2009). eWOM has been proved to influence consumers' decision-making processes in prior literature (Seiler *et al.*, 2017). When measuring the effects of eWOM, volume and valence were used widely. The volume measures the total amount of eWOM communication while the valence describes the eWOM positive or negative. Many studies proved that volume is more significant relative to consumer purchase decisions because it increases the awareness of the product (Seiler *et al.*, 2017). Conversely, the discussion about the effects of valence varies a lot. Some studies asserted that valence has no effect on consumer behavior (Duan *et al.*, 2008). Others found that valence significantly affects revenue (Chintagunta *et al.*, 2010) .

Microblogging, catering to young people who prefer scanning brief messages during their fragmented time, generated a new type of word of mouth—microblogging word of mouth (Hennig-Thurau *et al.*, 2012). The distinction of microblogging compared to other online communication platform lies in the convenience for updating by users with fragmented content. It enables information to spread rapidly (Kim *et al.*, 2014). Microblog also enables companies to promote communication and develop a mutually beneficial relationship with consumers (Kim *et al.*, 2014). The economic effects of Twitter have been proved in the music, movie, and game industries (Hennig-Thurau *et al.*, 2015). While Twitter has achieved great attention when studying consumers' eWOM, Sina Weibo in China is still underestimated, although it has grown to be a key eWOM platform with its rapid growth and widespread. The cultural difference can play an important role in deciding consumers' behavior on microblogs. The specific motivations for Sina Weibo members to engage in eWOM of films in China are worth exploring.

### **Motivations of eWOM in Virtual Communities**

Motivation is “an internal state or condition” which determines general behavior to a great extent (Reimer & Benkenstein, 2016). Although (Cheung & Thadani, 2012) developed a synthesized framework to study eWOM adoption as an integrative process, research on sharing eWOM still remains fragmented. Among them, (Hennig-Thurau *et al.*, 2004) made a great contribution by putting forward 8 explicit motives (i.e., platform assistance, venting negative feelings, concern for other consumers, extraversion/positive self-enhancement, social benefits, economic incentives, helping the company, advice-seeking) when studying consumers' engagement in generating eWOM on opinion platforms. However, a deeper understanding of members' motivation in virtual communities is still under exploring.

#### ***Egoistic motivations***

Egoism is defined as one's self being the motivation of one's behavior (Fu *et al.*, 2015). Egoism is an outlet for consumers to release their emotional needs for self-enhancement, such as gaining attention, improving reputation, or asserting expertise and superiority (Yang, 2017). Meanwhile, social benefits, including self-enhancement, can be achieved easily through positive eWOM communication since online platforms face a large number of people and can leave the message existing for a long time (Tong *et al.*, 2007). Egoistic motivations have been widely found to be an antecedent for positive eWOM (Fu *et al.*, 2015; Hennig-Thurau *et al.*, 2004). In addition, (Wallace *et al.*, 2014) studied Facebook fans suggested that self-expression can be relative to members' willingness to engage in the eWOM on the self-expressive medium such as Facebook.

#### ***Motivations for the reward***

Rewards, including monetary incentives, were found to be effective tools for increasing the eWOM (Reimer & Benkenstein, 2016). For example, (Hennig-Thurau *et al.*, 2004) identified economic incentives as one of the primary reasons for consumers to engage in eWOM communication. However, in the context of virtual communities, (Wallace *et al.*, 2014) found that rewards or can reduce intrinsically driven behaviors on Facebook. (McLure Wasko & Faraj, 2000) explained that systems based on rewards can quickly turn moral obligation in the virtual community into self-interest, which weakens the motivation for members to engage. Likewise, (Sun *et al.*, 2017) also suggested that monetary rewards only work for members with few social connections. Furthermore, monetary rewards may even demotivate well-connected members to contribute to the virtual community.

#### ***Reciprocal motivations***

Reciprocity was referred to the information exchanging that is mutual and supposed by the participant as fair in the context of eWOM (Kim *et al.*, 2014). The reciprocity explained the motivation for the valence of the eWOM. In specific, people who experience positive consuming experiences would generate positive eWOM due to the enjoyment in helping the company. On the other hand, the enjoyment of vengeance will motivate consumers to generate negative eWOM in return (Hennig-Thurau *et al.*, 2004). Similarly, positive eWOM was identified as the motivation for consumers to ease the tension raised by product involvement, while negative eWOM communication was viewed as a response to recover losses caused by unsatisfactory products or services (Fu *et al.*, 2015) .

#### ***Altruistic motivations***

Altruistic motivations have been proved to be important for consumers to engage in eWOM communication (D. Lee *et al.*, 2012). It was reflected in the desire to help others (Reimer & Benkenstein, 2016). People who are motivated by altruism share their own positive or negative consumption experiences for providing benefits to others without the expectation of reward (Tong *et al.*, 2007). In many research, the enjoyment of helping others was a primary motivation for people to generate eWOM (Hennig-Thurau *et al.*, 2004; Lee *et al.*, 2006) .

#### ***Motivations in the sense of community***

The sense of community was referred to as the obligation or commitment to engage in knowledge sharing, which can benefit the community (Majali & Bohari, 2016). It closely relates to the concept of social identity, which is defined as “the individual's knowledge that he belongs to certain social groups together with some emotional and value significance to him of this group membership” (Lee *et al.*, 2006). When individuals identify themselves as part of the group and line up their objectives with those in the group, they will be motivated to do something beneficial for others. Similarly, (Cheung & Lee, 2012) mentioned collectivism as motivation with an ultimate goal of increasing the welfare of a group when studying consumers' engagement in eWOM communication. The act for the public good is for the group's benefit, which is opposite to egoism.

## eWOM in Film Industry

Since producing and marketing motion pictures can be desperately risky (Hennig-Thurau *et al.*, 2007), Marketing research in this industry is fruitful. It has been found the volume of word of mouth at the end of the first week is the main driver of the long-term revenue (Roschk & Große, 2013). It suggested that prerelease weeks and opening week can be the critical period for film manufacturers to manage word-of-mouth marketing.

## METHODOLOGY

### Research Methods

Netnography was used in the research for studying virtual communities depending on the ethnographic research techniques (Brodie *et al.*, 2011). Since it develops from ethnography, one of its benefits is that the surroundings of the research environment are not created artificially. On the other hand, the online approach provides scope for studying a larger number of individuals (Wu & Pearce, 2014). Netnography is the most appropriate method to gain insight into word-of-mouth processes in virtual communities.

### Research Planning

Since it is important to study the participants with the specific marketing research questions when choosing the research site, we followed criteria suggested by (Kozinets, 2002) as follows: (1) a more focused and research question-relevant segment, topic, or group; (2) higher “traffic” of postings; (3) larger numbers of discrete message posters; (4) more detailed or descriptively rich data; and (5) more between-member interactions of the type required by the research question.

Bearing the research questions in mind, three new films were chosen as the #topic# in the eWOM on Sina Weibo. With the help of the conditional filter function on Sina Weibo, we chose the Weibo posted from prerelease weeks to the end of the opening week of each film which was guided by (Roschk & Große, 2013).

The questions were designed from the heated questions to the core questions. It first asks the respondent to share the perspectives on eWOM of films on microblogs and to identify the social relationship in the virtual community. The specific motivation for the engagement was asked for when letting respondents interpret the eWOM they engaged in before. In the end, the following up questions were used to broaden the depth of the interview. The model of a general topic guide can be found in Appendix A. After each interview, the questions would be reconstructed after gaining a better understanding.

### Research Process

#### *Data collection: 2000 Microblogs and 20 interviews*

From April 4th to July 15th, a total of 2000 under the requirement in the research planning was collected. Among them, the microblogs presenting the motivations from the perspectives of egoism, reward, reciprocity, altruism, or sense of community would be used as data. One of the most representative eWOM was quoted as an example for the results. Their provider's information which is public on Weibo, was collected as the supporting data. Second, the members who engaged eWOM with a representative motivation of one type were invited to participate in the qualitative research

20 respondents were chosen to be interviewed. Then the whole process of communication in the interview would be recorded. A sample of the transcript of the interview can be found in Appendix B. The data were collected and interpreted by using their pseudonym after gaining approval from them. However, when starting to analyze the data, the pseudonym was removed and identified as the number.

#### *Data analysis*

This study adopted a manual approach to analyzing the data because the data set is reasonable in size, and the researcher is very familiar with the data context (Kozinets *et al.*, 2010). An established qualitative data analytic process was adopted. According to (Pierre, 2017), two main steps would be involved. First, codes were assigned to words or segments of words. Then we started to compare and contrast the coded material. In later phases, the criteria for analysis were devised based on the experiential knowledge and learning established from the research progression and prior studies.

The distinction of netnography decided the diversity of the data. Textual and graphics files, screen captures, online interview transcripts, and reflective fieldnotes all need to be analyzed and interpreted to explore the motivation.

## RESULTS AND DISCUSSION

### Results of Egoistic Motivations

Egoistic motivations in eWOM of films in Sina Weibo consist of four specific motivations, i.e., gaining attention, improving reputation, asserting expertise and superiority, and self-expression as the main driver for consumers to engage in eWOM were found in the research. Table 1 illustrates each motivation and examples of each motivation from the data.

#### *Gaining attention*

It has been found in many microblogs that gaining attention from other members in Sina Weibo can be a critical motivation for them to engage in. Members in microblog used #film# to create the topic and to gain attention from other members who were interested in the film. In addition, social interaction with celebrities and peer members was found as a big motivation for members to generate eWOM. The relative eWOM was mostly constructed with the “@” to gain attention, as presented below:

Xu (star) 's acting skill is so great @Xu! Have you guys watched the perfect film already (A, July 5, 2018) ?

“@” celebrity in eWOM can gain the attention not only from the celebrity but also from other members on Sina Weibo who would search the name of the celebrity. Asking the question, Informant A was expecting a reply from other members on Sina Weibo in the comments below their eWOM.

In addition, data collected showed that members used Sina Weibo to connect with their friends in daily life. For example: inviting others to watch the film together by @ them in the positive eWOM of films. Sina Weibo seems to combine the strong tie and weak tie at the same time. However, some respondents suggested that lacking social interaction can be the biggest motivation for them to generate negative eWOM of films.

“Compared to the WeChat, there are much fewer friends and colleagues on my Sina Weibo. I do not reject their invitation. However, I feel that people on Sina Weibo have a consensus that we should not involve others’ depressed emotions too much. It means there will not be too much concern or attention from others when you post something negative.” Respondent 6

The weaker tie in Sina Weibo makes members feel free to generate negative eWOM without concerning attention from people in the strong tie.

“Sina Weibo is more like a tree hole in my daily life. There are no colleagues and leaders. I don't have to be concerned about my negative words, which may affect my image in their impression.” Respondent 3

By using the “tree hole”, Respondent 3 described Sina Weibo as the secret place away from the attention gained by others.

### ***Improving reputation***

Improving reputation was found as a motivation for members who have a large number of followers when they generate negative eWOM. Especially when their eWOM was catering to their followers’ opinion and was considered organic. The example of the comment below the negative eWOM can explain the circumstance precisely:

The modeling of the film plagiarized Game of Thrones. The plot is bloated and unworthy of discussion. The special effect looks only cost five cents. The texture of the movie is similar to online games. The movie lasted 140 minutes in which they could not even speak the whole story. Ignoring the unclear story, the action design in fighting scenes was a disaster (B, July 13, 2018) .

[Comment: You are the only one telling the truth about the film. Other film critics I followed took the money and ridiculously recommended the film.]

Data showed that members with many followers mostly criticize the film for improving their reputation. However, the motivation was not found in members with few followers.

### ***Asserting expertise and superiority***

Sina Weibo can be considered as a place for members to present their expertise or superior status by sharing a special experience or advanced knowledge. For example, interpreting the film themes or uncovering the hidden stories in film production was widely found in eWOM in the research. To be regarded as an expert, Sina Weibo members were found to share knowledge from different perspectives to analyze the movie. Thus, this kind of sharing contributed to high-quality eWOM.

In addition, gaining higher status can also be found as a motivation for members to share superior experiences and film reviews. As an intangible consumption, superior experience such as VIP room in cinema was hard to be shared in the traditional WOM. However, microblog provides a sharing platform that can help members share their superior experiences. Sina Weibo members were found to post pictures of an IMAX or VIP room in the cinema when talking about their watching experience. Special occasions such as roadshows or premieres were the main superior experience mentioned by members in the research. As in the example shown below, members shared the experience in the roadshow with photos of the scene:

#Happy summer film#&#Dying to Survive# Hahaha, I met the cute guy Xu Zheng (star). It is one of the best Chinese movies in recent years, combining comedy and humanity, as well as social contradictions. I have been walking into the theatre with a smile, then walking out in tears. It is worth watching (C , July 5, 2018) .

Meeting the actors and directors in person can be seen as a superior experience. Respondent 5 also gave a similar reason for generating eWOM of the film:

“I reviewed it only for recording a special watching experience. It was the first time I saw the movie stars. I felt so excited. However, the film was just so-so.” Respondent 5

Although she did not feel involved with the film, she was motivated to record and show the superior experience on Sina Weibo for the social need.

**Expressing oneself**

Using Sina Weibo as the medium to express oneself was widely found in eWOM collected in the research. This kind of egoistic motivation was found in the eWOM on films which has a positive WOM online. Members were found to use positive words making themselves related to the film theme.

# Dying to survive[film]# Nothing is more important than people’s health in our families. (I) will cherish the people around me. (I) will become stronger to protect them. All my loves, you have to be healthy and keep growing (D · July 8, 2018) .

By expressing the film reviews discussing the film theme, D expressed his/her attitudes toward life. Hence, posting selfies in the film reviews were found popular among Sina Weibo members as a tool to express themselves. Many film reviews consisted of simple words giving a general impression of the film (e.g., positive or negative) and a large portion of paragraphs describing their life record for the day. In the end, they will post pictures for each part, just as figure 1 shows.



Source: Sina Weibo.

Figure 1: expressing oneself.

The daily record can be an important function provided by Sina Weibo. When it comes to the fans of films, recording film reviews can be even more significant:

“I wrote the film review immediately after watching a film. It can record my feelings. After a while, you look back, and you can quickly recall the thoughts at that moment. It can witness your growth. Especially for those great films which are worth watching again, and again, you may have different feelings after watching them each time.” Respondent 3

“Online Diary” was used by 2 respondents when asked to describe the role of Sina Weibo in their daily life. Showing thoughts or selfies sometimes can be one of the important reasons for Sina Weibo members to generate film reviews online.

Table 1: Egoistic motivations.

Extrinsic	Motivation	Example from data
Egoism	Gaining attention	Xu Zheng (star) ’s acting skill is so great @Xu Zheng! Have you guys watched the perfect film already (A, July 5, 2018) ?
	Improving reputation	The modeling of the film plagiarized <i>Game of Thrones</i> . The plot is bloated and not worth to talk about. The special effect looks only cost five cents. The texture of the movie is similar to online games. The movie lasted 140 minutes in which they cannot even speak the story clearly. Ignoring the unclear story, the action design in fighting scenes was a disaster (B, July 13, 2018) . [Comment: You are the only one telling the truth about the film. Other film critics I followed took the money and ridiculously recommended the film.]
	Asserting expertise and superiority	#Happy summer film#&#Dying to Survive# Hahaha, I met the cute guy Xu Zheng (star). It is one of the best Chinese movies in recent years, combining comedy and humanity, as well as social contradictions. I have been walking into the theatre with a smile, then walking out in tears. It is worth watching (C, July 5, 2018) .
	Expressing oneself	# Dying to survive[film]# Nothing is more important than people’s health in our families. (I) will cherish the people around me. (I) will become stronger to protect them. All my loves, you have to be healthy and keep growing (D, July 8, 2018) .

**Results of Motivations for the Reward**

Reward motives vary in the film industry. The traditional economic incentives were not that attractive to consumers. While a new form of reward, such as superior experience, is more effective for engaging consumers into eWOM generation. Table 2 illustrates each motivation and examples of each motivation from the data.

### **Economic incentives**

Limited data collected in the research present a motivation for gaining the economic reward. However, on Sina Weibo, economic incentives developed into a new form to employ members. Winning film tickets was found as a motivation for some members to repost eWOM generated by others:

#film Asura in theatre 0713# I have been a huge fan of magical movies. The Asura is just what I want. The movie configuration is a giant screen effect, and I believe that the special effects of this movie will be great. After watching the trailer, I meditated that the film must be watched in the giant curtain hall. Looking forward to being chosen (E, July 13, 2018) .

The example shows the Sina Weibo member's desire to be chosen for getting the free film tickets. In addition, this kind of behavior was found mostly generated by members who have a small number of followers and limited interaction with them. On the other hand, the economic incentives can be considered against the community norm by some members.

"A film review is a private feeling, not the exchange for making money. The most important thing for film critics is to have their own opinion. They should not follow suit or be bought off." Respondent 1

As expressed by Respondent 1, generating film reviews for the monetary reward can be seen as betraying, which may hamper some members' motivation.

### **Superior experience**

Superior experience as a reward was also found in the result as a motivation for members to engage. As mentioned before, participating in special occasions can increase the members' perceived status in the community. When this kind of experience becomes a reward, some members were found motivated successfully to engage in film reviews:

@Sina film-watching groups @Film where are you going. The Asura was not satisfying. However, watching films in advance was fantastic. I will join if I get the chance next time (F, July 13, 2018) .

Informant F was chosen by Sina Weibo as a lucky audience to watch the film in advance. According to the regulation of the game, members have to generate the film reviews with their true thoughts after the experience, or they will lose the next chance for being chosen as the lucky audience to watch the new films previously forever. The superior experience of consuming films extended the range of rewards to engage members.

Table 2: Motivations for reward.

Extrinsic	Motivation	Example from data
Rewards	Economic incentives	#film Asura in theatre 0713# I have been a huge fan of magical movies. The Asura is just what I want. The movie configuration is a giant screen effect, I believe that the special effects of this movie will be great. After watching the trailer, I meditated that the film must be watched in the giant curtain hall. Looking forward to being chosen (E, July 13, 2018) .
	Superior experience	@Sina film watching groups @Film where are you going. The Asura was not satisfying. However, watching films in advance was fantastic. I will absolutely join if I got the chance next time (F, July 13, 2018) .

### **Results of Reciprocal Motivations**

Reciprocal motivations in eWOM of films explain the valence of eWOM of films. Celebrity endorsement and company endorsement were found accelerating the generation of positive eWOM. Conversely, terrible experiences, including false propaganda and unworthy high prices, made consumers feel deceived. The desire for vengeance motivated them to generate negative eWOM. Table 3 illustrates each motivation and examples of each motivation from the data.

### **Enjoyment in advocating the celebrity**

Advocating celebrities who are involved in the film can be a major motivation for the fans of the celebrity to engage in positive film reviews.

I think Wu Lei (star) acted well in Asura. I was sprinting for my high school entrance exam when Wu Lei was also sprinting for his high school entrance exam. By reading his Sina Weibo, I feel supported. In the end, I succeeded. Thank you! @WuLei. No

more malicious followers criticize the film. Please! Those actors made a lot of effort in making the film. Wu Lei also made a lot of effort (G, July 14, 2018) .

As shown in the example above, reciprocity happens when viewers gain support from the celebrity and wish to give support back to the celebrity.

#### **Enjoyment in helping the film succeed**

Enjoyment in helping the film succeed was found as members' motivation to engage in positive reviews after watching a satisfying movie:

I will give the full mark. The movie will attack your heart like a needle. It is the yearly best movie (H, July 8, 2018) .

Not only giving a positive review with emotional words but also playing a role of advertising the films to other members. For encouraging more people to watch the film, many people used “worth” “equal the value” to describe the film. Furthermore, some members even encourage others to watch more than one time for contributing to the box office. The desire to help the film succeed can also be found when members asserting this movie should get many awards. Since the success of the movie lies not only in the box office but also depends on the WOM. The behavior of posting positive film reviews can be seen helping the film succeed directly.

#### **Enjoyment in vengeance**

After watching an unsatisfying movie, members were found to engage in negative reviews for revenge. Compared with describing a positive watching experience, members were found to tend to use “unworthy”, “waste” to evaluate the film.

I cannot believe what the hell I watched in an IMAX cinema room. The guy beside me signed near the end of the film, (I) started to empty myself with the 3D glasses off and leaned on the shoulders of my friends when the story carried out for one and a half hours. #Asura##Asura (2018) [Films] rest in peace (I, July 15, 2018).

“IMAX” cinema was mentioned to emphasize the extra price Informant I paid for watching the film. The whole description of the frustrating experience suggested a dissatisfying consuming experience.

Interestingly, the negative experience was found not only produced in the watching experience. The improper valence of eWOM on Sina Weibo can also be the source of the negative impression, which may cause revenge from members.

“The flooded positive reviews generated by so-called “Sina Weibo influencers” who watched the film previously appreciating the films, however from superficial perspectives, made me sick. I bet that Hidden Man would fail in both the box office and word of mouth. So, when it was in the theatre, I went to watch it. Just as I said, Hidden Man is trash. So, I reported it on Sina Weibo and felt fair after doing that.” Respondent 2

Sina Weibo helps connect the film critics and the film audience; however, it also provides the medium for the audience to give negative feedback to them. Venting the negative feelings on Sina Weibo can make members feel fair after watching an awful movie or being exposed to fake film reviews.

Table 3: Reciprocal motivations.

Extrinsic	Motivation	Example from data
Reciprocity	Enjoyment in advocating the celebrity	I really think Wu Lei (star) acted well in <i>Asura</i> . I was sprinting for my high school entrance exam when Wu Lei was also sprinting for his high school entrance exam. By reading his Sina Weibo, I feel supported. In the end, I succeeded. Thank you! @WuLei. No more malicious followers criticize the film. Please! Those actors really made a lot of effort in making the film. Wu Lei also made a lot of effort (G, July 14, 2018) .
	Enjoyment in helping the film succeed	I will give the full mark absolutely. The movie will attack your heart like a needle. It is definitely the yearly best movie (H, July 8, 2018) .
	Enjoyment in vengeance	I cannot believe what the hell I watched in an IMAX cinema room. The guy beside me signed near the end of the film, (I) started to empty myself with the 3D glasses off and leaned on the shoulders of my friends when the story carried out for one and a half hours. #Asura##Asura (2018) [Films] rest in peace. (I, July 15, 2018) .

### Results of Altruistic Motivations

Altruistic motivations were found as reasons for consumers to engage in eWOM of films in Sina Weibo. However, motivation to help others avoid a negative experience with brief text less frequently appeared compared to motivation to help others get a positive experience. Table 4 illustrates each motivation and examples of each motivation from the data.

#### *Helping others get a positive experience*

Helping others was found as a motivation for members to engage in positive eWOM. Words such as “Highly recommend” or “must watch” were found frequently used in many Sina Weibo showing the altruistic standpoint of the writer, just as the example below:

Highly recommend *Dying to Survive*. You will not regret and have a better understanding of lives (J, July 8, 2018).

It was confirmed when Respondent 5 talked about the reason why she chose to repost the teaser posted by the film official on Sina Weibo.

“I think reposting the teaser of the film published by officials can let people know the general idea of the film more easily. I just added simple words to express my emotion after watching the film. It was not for generating a complete film review.” Respondent 5

Providing convenience and access for other members to choose films can be considered as an altruistic motivation for helping others to get good experience.

#### *Helping others*

In some eWOM, “Don’t go” or “not recommended” was found to warn other members to avoid the situation in which they were stuck.

I watched *Asura*, and I do not recommend watching it in the cinema. 2 hours, time-consuming and boring. (K, July 14, 2018)

However, this kind of eWOM is mostly constructed with few words and is seldom found in the research. Respondent 4 talks about the limited effect of eWOM he generated on Sina Weibo, which may explain the reason.

“I am not sure about the impact on my followers on Sina Weibo. But for my friends around me (in real life), it might help them avoid this film.” Respondent 4

The influence of the information sender on the information seeker was perceived as weak by the sender. Since the relationship on Sina Weibo has been found weak, it can explain the lacking altruistic motivation for eWOM engagement.

Table 4: Altruistic motivations.

Intrinsic	Motivations	Example from data
Altruism	Helping others get a positive experience	Highly recommend <i>Dying to Survive</i> . You will not regret and have a better understanding of lives (J, July 8, 2018).
	Helping others avoid a negative experience	I watched <i>Asura</i> , and I do not recommend watching it in the cinema. 2 hours, time-consuming and boring (K, July 14, 2018).

### Results of Motivations in the sense of community

eWOM generation resulting from the sense of community was found in the research. Two kinds of obligation prompted users to show their own opinion. One of them is to protect the welfare of film creators, and the other is to protect the benefits of the audience. Table 5 illustrates each motivation and examples of each motivation from the data.

#### *An obligation to protect the welfare of film creators*

Appreciating a high-quality film and criticizing a low-quality film, some members were found to have an obligation to judge the film with justice for keeping the environment of the film industry fair for the film creators. The example shown below suggests the motivation for improving the environment for film creators:

The most important is the progress in the audience's abilities of aesthetic appreciation. Now the films are not only reviewed by fans of actors or paid posters. More and more people review films by evaluating criteria depending on the quality of the film. I hope that more people will walk into the cinema to watch *Dying to Survive* to support the domestic movie (L, July 5, 2018) . Since Sina Weibo mostly gathers users from China, the motivation for supporting domestic films was found relative to patriotism. The obligation for protecting the whole welfare of the community presented in protecting the welfare of film creators.

"I reviewed the film because I hold an expectation for Chinese movies. I think the realism films, which is a movie genre rarely be seen in the Chinese film industry, are worth taking attention to." Respondent 1

The desire to help the specific film be successful can also be interpreted as the desire to help the movie genre gain attention, which brings benefits to film creators of the movie genre.

#### **An obligation to protect the benefits of audiences**

Protecting the benefits of audiences by supporting people in posting their film reviews against the mainstream opinions was found as a motivation for some members to engage in relative eWOM.

Some online reviews say that "people who criticize *Dying to Survive* are stupid and evil. Don't you think the evaluating system becomes frightening? Now the majority of the audience who hold positive reviews do not allow different opinions to exist. We must be cautious of those harmful film reviews (M, July 4, 2018) .

Providing a free and fair discussing environment for films on Sina Weibo can be included in the community norm by Informant M. Supporting the opposite review when facing the pressure from the majority can be considered as the sense of community.

Table 5: Motivations in the sense of community.

Intrinsic	Motivation	Example from data
Sense of community	An obligation to protect the welfare of film creators	The most important is the progress in the audience's abilities of aesthetic appreciation. Now the films are not only reviewed by fans of actors or paid posters. More and more people review the films by evaluating criteria depending on the quality. I hope that more people will walk into the cinema to watch <i>Dying to Survive</i> , to support the domestic movie (L, July 5, 2018) .
	An obligation to protect the benefits of audiences	Some online reviews say that "people who criticize <i>Dying to Survive</i> are stupid and evil. Don't you think the evaluating system becomes frightening? Now the majority of the audience who hold positive reviews do not allow different opinions to exist. We must be cautious of those harmful film reviews (M, July 4, 2018) .

#### **Discussion of Egoistic Motivations**

Five motivations of the eWOM generation were examined in the research. Some new findings can develop the construction of motivations when analyzing consumer engagement.

The egoistic motivations played a critical role in encouraging members to generate both positive and negative eWOM of films on the microblog. It explained the demand for social interaction from members and identified different roles in the virtual community. The results matched (Yang, 2017) that egoism is an outlet for members to release their emotional needs. Consistent with (Cheung & Lee, 2012), gaining reputation was found in eWOM generated by opinion leaders. The microblog was found as a good place for members to gain expertise status matching (Tong *et al.*, 2007), emphasizing the importance of the online platform. Furthermore, expressing oneself was found as a new motivation for microblog members to engage in eWOM. Earlier research (Wallace *et al.*, 2014) found that people were more willing to engage with a self-expressive brand on the self-expressive medium. The findings in this research gave further insight that self-expression can be a motivation for members to generate eWOM.

The results of motivations for the reward in the research didn't match (Reimer & Benkenstein, 2016) and (Hennig-Thurau *et al.*, 2004) that economic incentives act as an effective tool for encouraging members to engage in eWOM communication. On the other hand, consistent with (Wallace *et al.*, 2014), the economic incentives were found reducing members' intrinsic motivation to engage in eWOM communication. The results confirmed the suggestion by (Sun *et al.*, 2017) that monetary rewards are only motivating for members with few social connections and contributions in the virtual community. The reason was explained by Respondent 1 that engaging eWOM for economic incentives is against the community norm. In addition, it is worth noticing that other forms of reward, such as superior experience acting the same role of economic incentives, were found acceptable for members in the community as a motivation to engage in eWOM of films.

The reciprocal motivations were found consistent with members' perceived benefits from the film. It matched (Lin, 2007) that people consider the cost and benefits of the information exchange process. Earlier research found that product involvement can motivate consumers to generate a positive review for giving the emotional reward back. (Hennig-Thurau *et al.*, 2004) adopted it and transformed it into "helping the company". The results supported it, proving "Enjoyment in helping film succeed" as a similar motivation for giving back the positive impression to the source of the product or the service. However, it gave further evidence that celebrity involvement can also be a motivation for members to engage in positive eWOM communication. Microblog connects celebrities and consumers in daily life. Thus, the evaluation of benefits and cost starts earlier on microblogs than on other platforms such as consumer opinion platforms. The reciprocal motivation was also found when members generated negative film reviews. The result was showing members complaining about the dissatisfying product matched (Fu *et al.*, 2015) that consumers generate negative eWOM for recovering losses.

The results of altruistic motivations match (Reimer & Benkenstein, 2016) that helping others is a motivation for people to generate positive eWOM. However, it was not found a primary motivation which contradicts (Lee *et al.*, 2006) and (Hennig-Thurau *et al.*, 2004). The reasons can be explained by the weak tie in virtual communities on the microblog.

The results of motivations in the sense of community showed members on microblog consider the environment as a collectivity and engage in protecting others' benefits. It matched (Cheung & Lee, 2012) that collectivism can be a motivation for members to engage in WOM communication. Consistent with (McLure Wasko & Faraj, 2000), members considered providing fair eWOM of films as the moral obligation which should be the community norm on the microblog. Earlier research (Kozinets *et al.*, 2010) found that most opinion leaders distinguish themselves from other members in the community since they generate WOM mostly motivated by communal interest. However, the findings showed that the communal interest has been attached to peer members on the microblog. The reason probably was the blurring boundary between opinion leaders and opinion seekers in a new form of virtual communities.

## CONCLUSION

### Conclusions and Practical Implications

The purpose of this study was to explore why microblog members engage in eWOM of films on Chinese microblog-Sina Weibo. By using the method of netnography, five motivations were examined, and new findings help companies, the film industry, and scholars to better understand the reason behind consumers' engagement in eWOM.

First of all, the egoistic motivations to achieve members' social needs found in the research suggested that a product or service company should consider this increasing demand of social interaction when developing the activities or advertisement for satisfying consumers' desire for social needs, which can increase the volume of the eWOM.

On the other hand, motivations for the reward in the research were found less likely to motivate members to engage in generating both volume and valence of eWOM. The reason can be explained by relating with one of the egoistic motivations found in the research. Since the microblog can be considered as a platform for self-expression, showing motivations of getting economic incentives can be seen as decreasing one's reputation, which would be avoided by most microblog members.

Similarly, the weak effect of altruistic motivations was found both in the volume and valence of eWOM. It can be explained according to the weak tie in the community. The diversity of the strength in the social tie on microblogs can weaken members' motivation for helping others which should be noticed by the managers of microblogs when developing the relationship in the community relying on information exchange.

However, the findings in reciprocal motivations gave the warning that abusing the marketing strategy can lead to a flood of negative eWOM. The interaction on the microblog empowers the peer consumers in the community, which should be emphasized in the market.

The motivation in the sense of community was found in a new perspective which can extend the theory of MWOM defined by (Hennig-Thurau *et al.*, 2012). Combining a wide social relationship between film creators and film consumers, microblog can be considered as the ecosphere where members would concern about the welfare of the whole industry. In addition, the blurring boundaries between opinion leaders and peer consumers found on microblogs proved (Kozinets *et al.*, 2010) that the interaction between peer members should be paid much more attention.

In conclusion, the results of the research extended the knowledge of the virtual community of microblogs which can imply scholars, companies, and microblog platforms.

### Limitations and Areas for Further Research

The study entails some limitations. First, the study can only interpret from members' text or narratives showing the motivations. Those motivations hidden by members would be hardly explored.

Secondly, the microblog chosen by the research has a geographic restriction that can only approach Chinese users. Therefore, the motivations of the sense of community can be localized. For example, data showed the patriotism plays a critical role in

members' sense of community which may not exist on the international microblog-Twitter. Further research can test the effect on different platforms to generate a better understanding of the MWOM.

Last but not least, some relationship between different types of motivation is shown in the result presented. Future research can examine the relationship between each motivation and its effect on members' behavior.

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### APPENDIX A: Topic Guide

#### Interview Questions:

1. Have you watched a film recently?
2. If yes, did you enjoy it? How did you know about the film? Do you believe the source of information? Which kind of recommendation do you identify as the most credible?
3. If not, when you want to watch films, what kind of recommendation do you mostly go for?
4. Will you engage with those recommendations on Weibo? Why?
5. Can you share with me the most unforgettable experience of film-watching? Did you review it online? Why did you choose to express your feelings or make the recommendation through...rather than...?
6. In what kind of circumstance will you engage with negative online reviews about the films on Weibo?
7. Let’s talk about the online review on...you posted on Weibo. Tell me about the factors that encourage you to engage with the review of it.
8. Why did you choose (the specific form of engagement) rather than other forms of engagement on Weibo?
9. What kind of role of Weibo in your daily life?
10. How much effect do you think your online review can make on your followers or visitors? What kind of role do you think you are playing when your followers or visitors seek advice on the film on Sina Weibo?
11. Did you discuss the film with your family or friends?
12. If yes, what difference is between the experience when you talk about the film with family or friends compared to doing those in Sina Weibo?
13. If not, why did you choose to express that online rather than family or friends?
14. Do you follow one Sina Weibo blogger who engages with the online review often on film?
15. If yes, do you think he/she is credible? What motivations do you think he/she have when engaging with the online review?
16. If not, can you describe a credible Sina Weibo blogger who makes the review on films? What characters he/she should have?

#### Follow-up questions:

1. Please tell me more about that
2. What you are sharing is important. Can you say more?
3. Could you say some more about that? What do you mean by that...?
4. Compared to your last experience, what is the biggest motivation this time for you to engage?
5. Tell me more about that experience when you chose to engage.
6. How do you see that in the future?
7. If you could change anything about that experience of engagement, what would it be?
8. Is there anything you would like to add?

### APPENDIX B: Sample Transcription

(R: researcher, R5: respondent 5)

**R: Have you watched the film recently? Do you like it?**

R5: I watched *Dying to survive* recently; I love it very much.

**R: How did you know the film?**

R5: I watched the teaser of the film on Weibo posted by We-media and saw the reviews on Weibo from big V (Weibo influencer) who attended the testing screening. Then I decided to go and watch.

**R: Do you believe the source of information?**

R5: I don't trust the recommendation from big V, who only post-film critics. But I trust the reviews from big V who attended the International film festival in Shanghai where they watched the film previously.

**R: Can you please share with me the most unforgettable experience of watching a film?**

R5: The roadshow of Gold Buster in Chengdu. It was a testing screening with the main creators showing up in the cinema.

**R: Did you review it online?**

R5: Yes, I did. I reviewed it only for recording a special watching experience. It was the first time I saw the movie stars. I felt so excited. However, the film was just so-so.

**R: Under what circumstance will you involve in negative reviews of the films on Weibo?**

R5: After watching a total trash film. Last time, I watched Guilty of Mind. The plot was terrible, the acting of a starring actor was unqualified. The whole film was disappointing. So after watching it, I searched for the film on Weibo to see other audiences' feelings. When I found reviewers who hold similar opinions with me, I would "Like" or "comment" on their Weibo to show my agreement with them.

**R: Ok, let us talk about your film review on Weibo. Can you tell me what encouraged you to review the Dying to Survive on Weibo?**

R5: My Weibo got huge attention and reviews because I watched the testing screening of the film and generated the Weibo before it formally came out. It was a film with a realism theme which can be rare in the Chinese film market. I wished the film could be caught the attention of others on Weibo. And in that Weibo, I emphasized the impression for the acting skills of starring actors.

**R: Why did you choose to repost the teaser published by the official film marketing account on Weibo and comment on it as a form of engagement rather than other types, such as writing original film reviews?**

R5: I think reposting the teaser of the film published by officials can let people know the general idea of the film more easily. I just added simple words to express my emotion after watching the film. It was not for generating a complete film review.

**R: Compared to the experience that you had before, what is the difference between these two experiences?**

R5: The film I reviewed before was not a recommended one. I reviewed it only for recording a special watching experience. However, this time, Dying to Survive is the film that I highly recommend, so I emphasized the quality of the film.

**R: What role does Weibo play in your daily life?**

R5: Social media. It is a platform for me to quickly achieve the information that I seek. Most of the time, it is for killing time. Sometimes I would share some daily-life experience on it.

**R: How much do you think your film review would affect your followers or visitors? What role do you play when your followers search for information about the films on Weibo?**

R5: I would say I can provide a reference as the help for them to decide whether they should watch the film. Since I am still a common user without much influence or commercial value as those big V. My followers or the visitors would only see me as an acquaintance who watched the film before, it is more credible.

## Multimodal Sentiment Analysis Based on Deep Learning: Recent Progress

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### ABSTRACT

Multimodal sentiment analysis is an important research topic in the field of NLP, aiming to analyze speakers' sentiment tendencies through features extracted from textual, visual, and acoustic modalities. Its main methods are based on machine learning and deep learning. Machine learning-based methods rely heavily on labeled data. But deep learning-based methods can overcome this shortcoming and capture the in-depth semantic information and modal characteristics of the data, as well as the interactive information between multimodal data. In this paper, we survey the deep learning-based methods, including fusion of text and image and fusion of text, image, audio, and video. Specifically, we discuss the main problems of these methods and the future directions. Finally, we review the work of multimodal sentiment analysis in conversation.

*Keywords:* Multilingual, sentiment analysis, pre-trained language models, BERT, GTP.

### INTRODUCTION

Sentiment Analysis (SA) is a process of analyzing, processing, inducing, and reasoning about personal texts with sentimental colors (Liu & Zhang, 2012). Hence, SA can help businesses improve their products, people make choices of products, and governments understand people's preferences. With the development of social networks, more and more users tend to use multiple media forms (i.e., texts plus images, animated pictures, emoticons, songs, and video) to express their opinions and sentiments. This is because "a picture is worth a thousand words," although it cannot express sentiment independently of the text but serves as an auxiliary part to remind the salient content in the text (Truong & Lauw, 2019). Generally, psychological research on sentiments shows that the pitch, intensity, speed of speech, and speech quality in speech play an essential role in SA (Hamsa *et al.*, 2020). So, it is reasonable to expect that SA on the fused information from multiple modalities is better than SA on texts only.

Thus, to understand better people's attitudes or views on certain events or topics, it is necessary for researchers to pay more attention to the SA of multimodal contents fused with text, image, and audio (Huddar *et al.*, 2020a, b; Harish & Sadat, 2020). Multimodal SA (MSA) uses Natural Language Processing (NLP), information fusion, machine learning, and Deep Learning (DL) methods to identify the subjective attitude of users through features extracted from multimodal data (text, image, voice, and video data) (Ji *et al.*, 2015; Abburi *et al.*, 2016). More specifically, MSA aims to identify and classify users' attitudes and opinions from all the aspects of words, visual and auditory. Its ultimate goal is to improve the accuracy of sentiment classification and to achieve the best prediction.

Recently, Deep learning (DL) played a vital role in image recognition, speech processing, and NLP (Soleymani *et al.*, 2017). This is because DL gets rid of the constraints of feature engineering and can achieve good output through training and optimization of parameters, and it has good domain adaptability. Basically, these problems are some classification problems. SA is also a problem of complex and subjective cognitive classification. So, surely DL technology can help SA (Xu *et al.*, 2019; Kumar *et al.*, 2020; Cai *et al.*, 2019), especially MSA (Zhang *et al.*, 2020a).

In this paper, we survey various DL-based methods for MSA. The three main problems in MSA are multimodal representation learning, multimodal alignment, and multimodal information fusion. The third is the core challenge in MSA because (1) the information of different modalities may not be completely aligned in time, some modal signals are dense, and some modal signals are sparse; (2) it is difficult for fusion models to utilize the complementarity between modalities; and (3) the type and intensity of noise in different modal data may differ. So in this paper, we focus on the fusion methods.

The current multimodal information fusion methods mainly include two types: feature-level fusion (Pérez-Rosas *et al.*, 2013) and decision-level fusion (Yu *et al.*, 2020; Zhang *et al.*, 2020c). Besides, there is a combination of the two, which not only

retains the advantages of the two but also overcomes their shortcomings (Harish & Sadat, 2020). Table 1 summarises the advantages and disadvantages of different fusion mechanisms.

Table 1: Multimodal information fusion classified by level.

Mechanism	Input	Approach	Output	Advantage	Disadvantage	Classifier
Feature-level fusion (Pérez-Rosas <i>et al.</i> , 2013)	Monomodal eigenvector	Feature fusion unit	Multimodal eigenvector	grasp the correlation between multimodal features.	cannot merge modal features directly, need shared space	Single classifier
Decision-level fusion (Yu <i>et al.</i> , 2020)	Monomodal eigenvector	extract and classify the features of each modal to obtain the local decision result and then fuse local decision results	the final decision vector	simpler and more free can produce locally optimal results	Time-consuming	Multiple classifiers
Feature/decision level fusion strategies (Harish & Sadat, 2020)	Monomodal eigenvector	Feature layer fusion and decision layer fusion	Decision vector	grasp the correlation between multi-modal features and produce local optimal results	-	Multiple classifiers

Source: This study.

According to the specific operation classification in the information fusion process, the information fusion methods mainly are simple oration-based fusion, attention-based fusion, and bilinear pooling-based fusion (Zhang *et al.*, 2020a). Simple oration-based fusion (Anastasopoulos *et al.*, 2019), such as cascade and weighted sum operations, has the advantage of weak parameter correlation and less impact. The attention mechanism applied to information fusion is that the feature vectors of different modalities are weighted differently to generate the final joint feature vector representation. Training of weight parameters is the key. The bilinear pooling method (Tenenbaum & Freeman, 2000) creates a joint representation space by calculating the image and text feature vectors. However, the model's dimensionality based on the bilinear pooling is very high, and the associated model can only be effectively trained when dealing with high-dimensional problems.

There exist some surveys on SA, but they are different from ours. From the aspects of Regarding linguistic, audio, and visual features, Jazyah and Hussien (2018) survey the studies of SA before 2018. Kaur and Kautish (2019) compare the studies of SA before 2019. However, both of them do not concern SA tasks on datasets of multiple modalities. Nor do our two surveys on SA published in 2020 (Lin & Luo, 2020a,b)(which focuses are on machine learning-based and SA application, respectively). In our survey (Lin *et al.*, 2020) in 2020, Section VI is entirely devoted to MSA. However, the eight studies mentioned there are different from ours in this paper, and the tables in the two papers are different. Moreover, this paper graphically compares the performances of various methods, but the previous one did not. In addition, in this paper, we summarised the latest work on MSA in 2021, but the previous does not. Soleymani *et al.* (2017) survey studies of MSA, but all of them are before 2017. Rather, our survey in this paper covers the work in 2020 and 2021, and our focus is on deep learning-based methods for handling three different MSA tasks. Although Zhang *et al.* (2020a) survey some models and training methods used for multimodal intelligence, they focus on the fusion of NLP and visual information rather than MSA. Baltrušaitis, Ahuja, and Morency (2018) investigate the state-of-art in multimodal machine learning and introduce general algorithms, but they are concerned little about MSA. Abdu, Yousef, and Salem (2021) summarised the multimodal video sentiment analysis based on deep learning methods. Zhang, Wang, and Liu (2018) provide a comprehensive survey of DLbased SA methods published before 2019, while our survey in this paper covers the methods proposed in 2019-2021. And ours focus on MSA, but theirs does not. Dang, Moreno--García, and De la Prieta (2020) review the latest research on DL-based for general SA rather than MSA, which is our focus in this paper. The survey of Prabha and Srikanth (2019) focuses on the various flavors of the deep learning methods used in different applications of sentiment analysis at the sentence level and aspect/target level. It concerns only the modality of text in SA, but ours in this paper concert multimodality in SA.

The rest of this paper is organized as follows. Firstly, we review DL-based methods for static MSA on text and image. Secondly, we brief DL-based methods for dynamic MSA on text, image, audio, and video. Thirdly, we discuss MSA in conversation. Finally, we conclude this paper.

## FUSION OF TEXT AND IMAGE

This section mainly discusses static MSA on text and image.

### Multi-Interaction Memory Network

To capture the impact of aspects on text and images and the multiple interactions associated with text and images, Xu *et al.* (2019) propose a Multi-Interaction Memory Network (MIMN) aspect-based MSA. The model can learn not only the

interactive influence between cross-modal data but also the self-influence of single-modal data. The model consists of two interactive memory networks that model text and image data to supervise given aspects of text information and visual information, respectively. They also construct a new publicly available multimodal data set from data captured from ZOL.com (China's leading IT information and business portal). Their experiments show that MIMN outperforms the state-of-art text-level SA methods. It can be seen from the experiment that the model proposed by them is better than all the comparison methods, and the best accuracy is 61.59%, and the Macro-F1 is 60.51%. In the future, it is worth doing more research on the intersection of aspect level and MSA.

### Deep Multimodal Attention Fusion

To exploit the discriminative features and the internal correlation between visual and semantic contents in social media data, Huang *et al.* (2019) propose a deep multimodal attention fusion model. First, it uses the semantic attention mechanism to learn the sentiment classifier of texts and uses the visual attention mechanism to learn the sentiment classifier of images. The goal of these two classifiers is to capture the sentiment-related words in a text and the sentiment-related information in an image area. Second, to use the complementary information in different modalities, they propose a fusion multimodal attention model for mining the correlation between different modal features. Finally, they use intermediate fusion and post-fusion strategies to integrate visual attention, semantic attention, and multimodal attention for sentiment prediction. On the data sets of Getty, Twitter, and Flickr, their experiments show that their model outperforms a state-of-the-art DL method for SA (Zadeh *et al.*, 2017) in terms of accuracy. And the accuracy of the data set Getty, Twitter, Flickr-w, and Flickr-m is 86.9%, 76.3%, 85.9%, and 85.9%, respectively. In the future, it is worth further exploring fine-grained MSA and studying whether their model can be extended to deal with other modal data (such as audio and video).

### VistaNet

To rely on visual information as alignment for identifying the important sentences of a document using attention, Truong, and Lauw (2019) propose an optical attention network for MSA, namely VistaNet. They believe that images only play a supplementary role in the SA of comments because images cannot tell the whole story alone. So, they do not directly use images for feature classification but can play another role. In other words, as a visual means to divert attention to the most prominent sentence or aspect in a comment. VistaNet has a three-tier architecture that summarises the representation from words to sentences, then to image-specific document representation, and finally to the final document representation. The model is tested on restaurant reviews, and it may be extendable to other types of web documents, such as blog posts, tweets, or any documents containing images. Their experiment that their accuracy rate reaches 61.88%.

### CNN based method

To take advantage of the combination of deep learning networks and machine learning to deal with text and vision, Kumar *et al.* (2020) propose a method for MSA on written texts and still images. It consists of the four modules as follows. (1) Discretisation: It employs Google Lens to separate the text from an image, then sends the text and the image to the text analytics and image analytics modules, respectively. (2) Text analytics: It determines the sentiment using a hybrid of a Convolutional Neural Network (CNN). (3) Image analytics: It uses a support vector machine (SVM) classifier (trained using bag-of-visual words) to predict the visual content sentiment. (4) Decision module: It validates and categorizes the output based on five fine-grained sentiment categories: highly positive, positive, neutral, negative, and highly negative. Their experiments show that their accuracy is nearly 91%, which is better than those by the text and image modules separately.

### BiLSTM based method

To detect multimodal sarcasm in tweets consisting of texts and images in Twitter, Cai *et al.* (2019) created a new dataset for multimodal Twitter satire detection, and they propose a multimodal hierarchical fusion model for MSA. In the task of modal feature extraction, they first extract image features and attribute features and then use image features and attribute features combined with Bidirectional LSTM (BiLSTM) to extract text features. In the multimodal information fusion task, they use a weighted average method to fuse the eigenvectors of single-modal to generate multimodal eigenvectors. The weighted average process improves the characterization of each modal feature and is better than the ordinary single modal feature splicing effect. Their experiments show that image attributes can make up for the blank high-level abstract information between text features and image features. In their own data set, the accuracy rate reached 83.44%.

Huddar *et al.* (2021b) propose a method for multimodal contextual fusion. First, it uses a BiLSTM with an attention model to extract important contextual information among the utterances. Then it fuses two-two modalities at a time. Finally, it fuses all three modalities. Their experiments show that their method outperforms the existing methods by over 3% on datasets IEMOCAP and over 2% on dataset CMU-MOSI.

### EF-Net

To process and analyze different aspects of distinguishing modalities that correspond to one target, Wang *et al.* (2021) propose an Attention Capsule Extraction and Multi-head Fusion network (EF-Net) for MSA. This model uses a two-way GRU and multi-head self-attention mechanism (MHA) to encode the semantic information of the text, using the ResNet-152 model and

capsule. The network processes images, and the integration of MHA and capsule network aims to capture the interaction between multimodal inputs. In addition to the target aspect, information from context and images is also used for emotional transmission. They manually annotated the two public TMSA datasets, Twitter15 and Twitter17. On the TABMSA task, EF-Net significantly outperforms the baseline model, with accuracy rates of 73.65% and 67.77% on the Twitter15 and Twitter17 datasets, respectively.

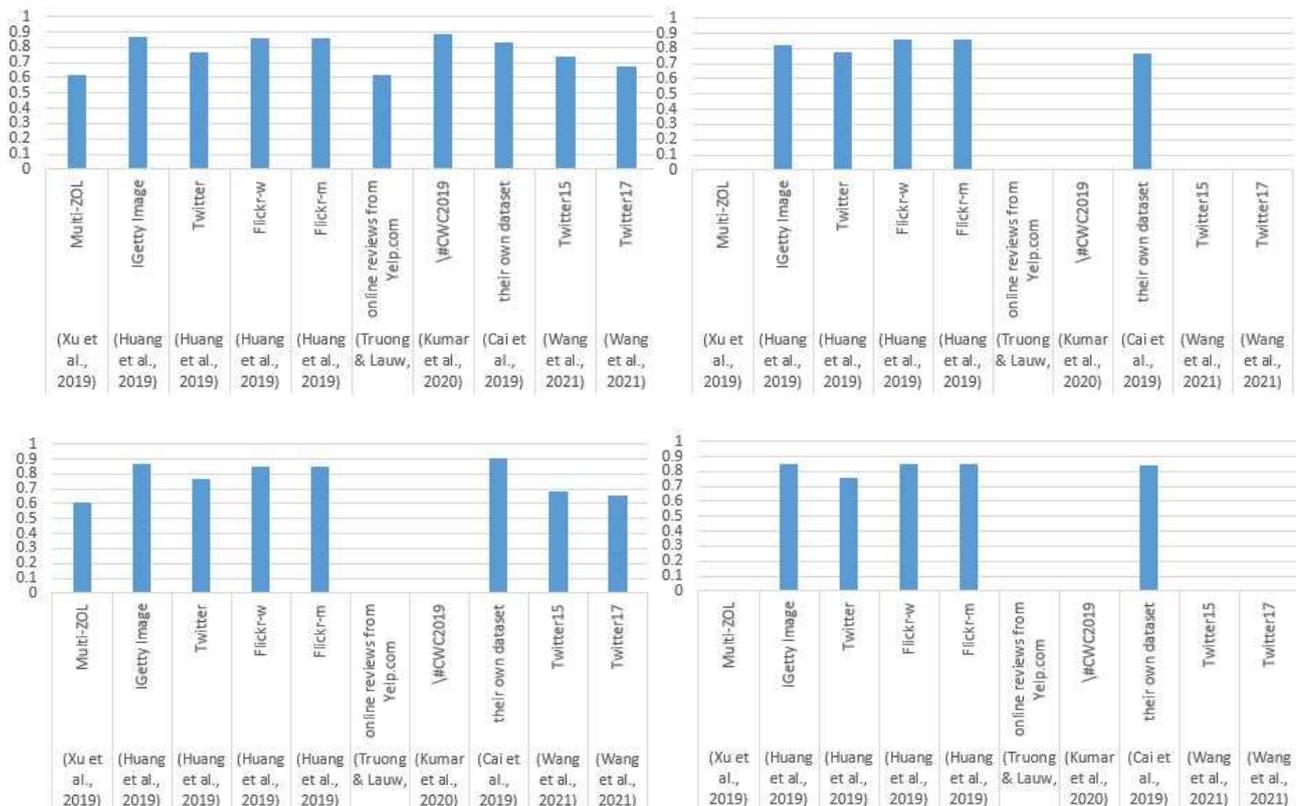
### Remark

Table 2 compares these methods, and Fig. 1 compares their performances. With the support of massive amounts of data, DL-based methods for MSA far outperform machine learning-based MSA models. However, DL-based methods have their own limitations. For example, DL requires massive amounts of data (the small amount of data leads to the trained model overfitting). And DL still lacks interpretability (Zhong *et al.*, 2019). In practice, the long training time and high computational complexity of DL models are also major problems. Nevertheless, DL is still a popular method for processing MSA tasks.

Table 2: Cross-lingual pre-trained models for SA.

Reference	Learning	Data set	Sentiment category
(Xu <i>et al.</i> , 2019)	Multi-Interaction Memory Network	Multi-ZOL	an integer sentiment score from 1 to 10
(Huang <i>et al.</i> , 2019)	Deep Multimodal Attention Fusion	IGetty Image, Twitter, Flickr-w, Flickr-m	positive and negative.
(Truong & Lauw, 2019)	VistaNet	online reviews from Yelp.com	on the scale of 1 to 5 as five sentiment levels.
(Kumar <i>et al.</i> , 2020)	CNN based method	#CWC2019	positive, negative, very positive, and very negative
(Cai <i>et al.</i> , 2019)	BiLSTM based method	their own dataset	Positive and negative
(Wang <i>et al.</i> , 2021)	EF-Net	Twitter15 and Twitter17	Positive, negative, and neutral

Source: This study.



Source: This study.

Figure 1: Performance comparison of various deep learning-based methods for static MSA.

## FUSION OF TEXT, IMAGE, AUDIO, AND VIDEO

This section discusses dynamic MSA on text, image, audio, and video. Some commonly used dataset for MSA are CMU-MOSI (<http://multicomp.cs.cmu.edu/resources/cmu-mosi-dataset/>), MELD (<https://affective-meld.github.io/>), IEMOCAP (<https://paperswithcode.com/dataset/iemocap>), MOUD (<http://multicomp.cs.cmu.edu/resources/moud-dataset/>), CMUMOSEI (<http://multicomp.cs.cmu.edu/resources/cmu-mosei-dataset/>), RAVDESS (<https://smartlaboratory.org/ravdess/>) and eINTERFACE'05 (<http://www.enterface.net/results/>).

### DeepCU

To extract the common information from visual, text, and audio, Verma *et al.* (2019) propose an MSA model with universality and uniqueness, called DeepCU. Firstly, they use a deep convolutional tensor network to extract standard information from the multimodal representation. Secondly, they use a unique subnet to obtain modality-specific information. Finally, they integrate the two aspects of information through the fusion layer, which enhances the generalization performance of the MSA system. Their model outperforms existing technologies. In the future, they plan to introduce the attention network into the fusion layer to integrate the information obtained by the two subnets efficiently.

### LSTM based method

To capture contextual information from their surroundings in the same video, Poria *et al.* (2017) analyze the context-related sentiments in user-generated videos. Specifically, they use textCNN to extract text features, openSMILE to extract audio features, 3D-CNN to extract visual features, and context-sensitive LSTM to extract the shared information among multimodal features. Their experiments show on datasets IEMOCAP, MOSI and MOUD, the accuracies are 76.1%, 80.3%, and 68.1%, respectively. Context-sensitive learning paradigm plays a key role in improving the model's performance. The model's performance on multimodal data (e.g., text-audio or text-video or text-audio-video) is better than that on single-modal data. For example, on dataset MOSI its accuracy is 78.12% on the monomodal data set of text, and its accuracy is 80.30% on the multimodal data set text-audio-video. Their experiments on the MOUD dataset show that visual information is more powerful than text and audio information.

### M3ER

To learn to emphasize the more reliable cues and suppress others on a per-sample basis, Mittal *et al.* (2020) propose a learning-based model for MSA, called M3ER. It can use a multiplicative fusion layer to fuse cues from three co-occurring modalities of face, speech, and text. The layer can learn which modality should be relied on more for making a prediction. It is also more robust than other methods to sensor noise in any individual modality. This is because they introduce a modality check step that uses Canonical Correlational Analysis to distinguish ineffective modalities from effective modalities. Their experiments show that a mean accuracy of 82.7% on IEMOCAP and 89.0% on CMU-MOSEI, together meaning an improvement of about 5% over previous work.

### MA-RNN

To fully use heterogeneous data, Kim and Lee (2020) propose a Multi-Attention Recurrent Neural Network (MA-RNN) for MSA on multimodal data of text, audio, and video. MA-RNN consists of two attention layers and a Bidirectional Gated Recurrent Neural Network (BiGRU). The first attention layer fuses data and reduces dimensionality. The second attention layer augments BiGRU to capture essential parts of the contextual information among utterances. In the feature extraction task, they use CNN to extract text features; use the open-source software openSMILE to extract audio features (such as pitch and voice intensity); use 3D-CNN to extract video features; and finally, use a fully connected layer to merge single-mode features. Their experiments show that MA-RNN achieves the state-of-the-art performance of 84.31% accuracy on the CMUMOSI dataset. Compared with the model without the attention mechanism, MA-RNN improves the accuracy by 17%.

### TransModality

To reflect the information from the source modality and the target modality, the feature body can be learned and inspired by the recent success of Transformer in machine translation. Wang *et al.* (2020b) propose a fusion method, TransModality, for MSA. It is an end-to-end translation model with Transformer, which can mine the subtle correlation between modalities. Specifically, Transformer encodes the features of one modal and decodes it into features of another modal (the target modality) when outputting. They believe that sentimental polarity is related to not only mono-modal characteristics but also the connection between modalities. Using Transformer, the learned features contain the information from the source modality and the target modality. On multimodal datasets CMU-MOSI, MELD, and IEMOCAP, their experiments show that TransModality achieves state-of-art performance.

### Synch-Graph

To emphasize the importance of constant interaction and co-learning between modalities, Mansouri-Bensassi and Ye (2020) propose an MSA method based on neural synchrony in multisensory audio-visual integration in the brain called Synch-Graph. Specifically, they use Spiking Neural Networks (SNN) to model the interaction between modalities, hoping to improve emotion classification accuracy. Many existing MSA methods focus on extracting features on each modality but ignore the importance of the interaction between modalities (Nian *et al.*, 2019; Zhang *et al.*, 2019). So, learning the interaction is the vital contribution of their model. They also use Graph Convolutional Networks (GCN) to learn neural synchrony patterns. Their experiments show that Synch-Graph achieves the overall accuracies of 98.3% and 96.82% on two state-of-the-art datasets,

respectively. In the future, it is worth examining the robustness of Synch-Graph on more massive data sets and studying the data representation problem after fusion.

### Unimodal Reinforced Transformer

To explore the time-dependent interactions within unaligned sequences, He, Mai, and Hu (2021) proposed a unimodal reinforced Transformer with time squeeze fusion for MSA. In inferring emotions from language, sound, and visual sequences, previous research focused on analyzing aligned sequences, while unaligned sequence analysis is more practical in real scenes. Due to the long-term dependence hidden in the multimodal unaligned sequence and the lack of time alignment information, it is more challenging to explore the time-dependent interaction in the unaligned sequence. They introduced time squeeze fusion, which automatically explores time-related interactions by modeling unimodal and multimodal sequences from the perspective of compressed time dimensions. Their model achieved the most advanced performance in terms of accuracy and F1 score on the MOSEI dataset.

### Lightweight Deep Neural Networks

To extract features of an audiovisual data stream that are fused in real-time for sentiment classification, Yakaew, Dailey, and Racharak (2021) propose a multimodal deep learning method. This method is suitable for automatic real-time analysis of emotions in the retail industry. They use modules based on small neural networks to dynamically content emotions from input video streams. They merge visual and auditory emotional characteristics and use fast-moving averages for emergencies, which become the final prediction. This article proves the use of lightweight predictive neural hierarchy. The network improves the feasibility of emotion classification performance based on multimodal processing in real-time on video data. The accuracy of this method in the Ryerson Emotional Voice Audiovisual Database (RAVDESS) reaches 90.74%.

### Channel-aware Temporal Convolution Network

To reflect that the language modality is far more important than the acoustic and visual modalities, Mai, Xing, and Hu (2021) propose an MSA method based on a channel-aware temporal convolutional network with LSTM. Specifically, to enhance the language representation through the corresponding auxiliary modalities. Besides, they also introduced a “channel aware” time convolutional network to extract high-level representations of each mode to explore the interdependence between time and channel. Their experiments show that their method outperforms three widely used benchmarks of MSA.

### Multi-head Attention Mechanism

To extract unimodal features and design a robust multimodal sentiment analysis model, Xi, Lu, and Yan (2020) proposed a method of extracting emotional features from vision, audio, and text and used these features to verify the MSA model based on a multi-head attention mechanism. Their experiments show that on datasets MOUDI and MOSI, its accuracy rates are 90.43% and 82.71%, respectively, meaning it is effective.

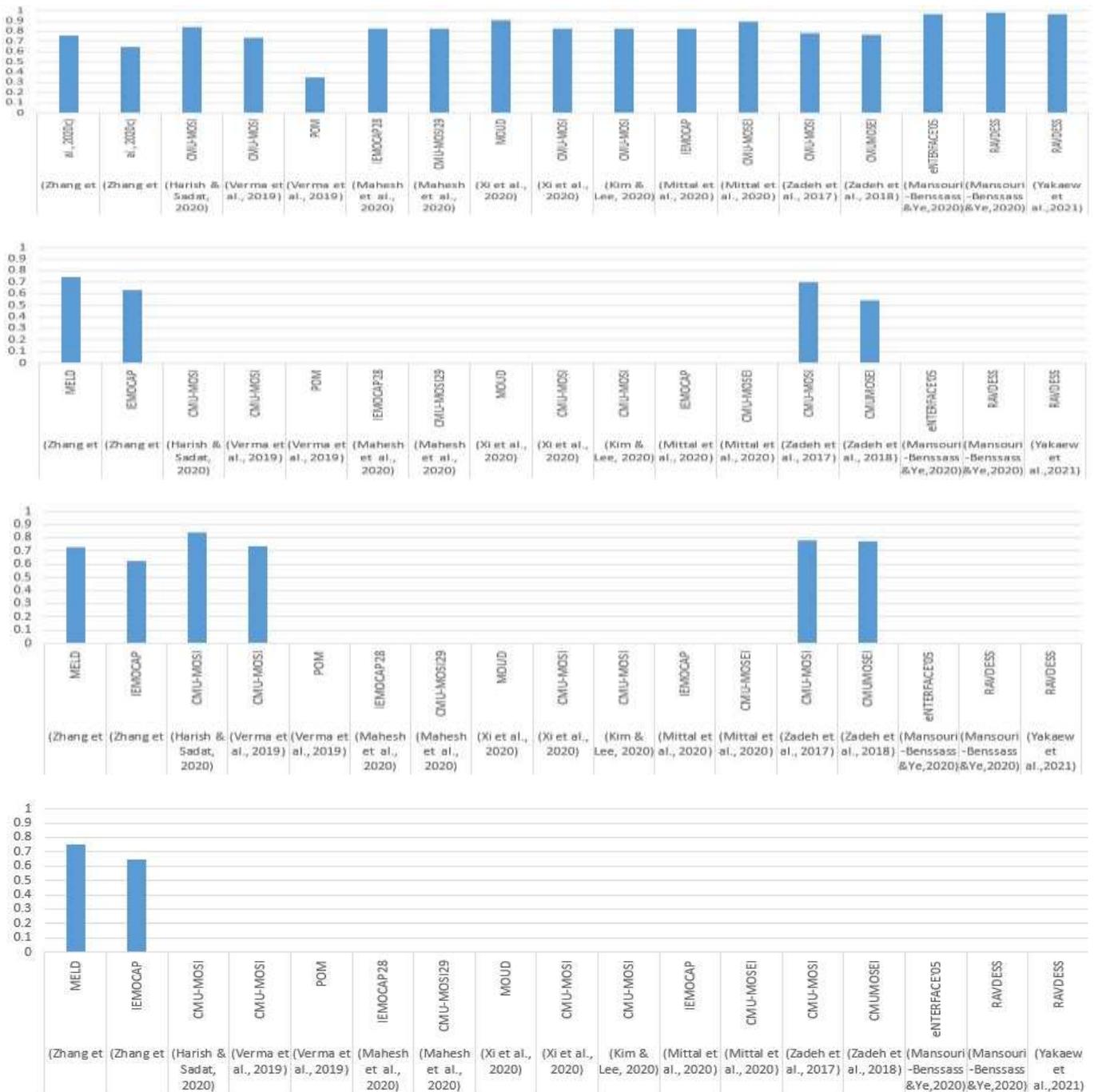
Table 3: Comparison of various deep learning-based methods for dynamic MSA.

Reference	Learning	Data set	Sentiment category
(Verma <i>et al.</i> , 2019)	DeepCU	CMU-MOSI and POM	CMU-MOSI: positive and negative, POM: 16 sentiments
(Mahesh <i>et al.</i> , 2020)	BiLSTM	IEMOCAP28 and CMU-MOSI29	IEMOCAP28: angry, happiness, neutral, and sadness; CMU-MOSI29: positive and negative.
(Zhang <i>et al.</i> , 2020c)	QT-LSTM	MELD, IEMOCAP	MELD: positive, negative, neutral, anger, disgust, fear, joy, neutral, sadness, surprise; IEMOCAP: anger, happiness, sadness, neutral.
(Harish & Sadat, 2020)	Attention-based DNN	CMU-MOSI	positive and negative
(Xi <i>et al.</i> , 2020)	Multi-head attention mechanism	MOUD, CMU-MOSI	Positive and negative
(Kim & Lee, 2020)	MA-RNN	CMU-MOSI	Positive and negative
(Mittal <i>et al.</i> , 2020)	M3ER: learning-based method	IEMOCAP, CMU-MOSEI	IEMOCAP: angry, happy, neutral, sad; CMU-MOSEI: anger, disgust, fear, happy, sad, surprise.
(Zadeh <i>et al.</i> , 2017)	Tensor fusion network	CMU-MOSI	5-class and binary
(Zadeh <i>et al.</i> , 2018)	Dynamic fusion graph	CMUMOSEI	Anger, disgust, fear, happiness, sadness, and surprise.
(Mansouri - Benssassi & Ye, 2020)	Synch-Graph	eNTERFACE'05 and RAVDESS	Anger, disgust, fear, happiness, sadness, and surprise

(Yakaew <i>et al.</i> 2021)	Unimodal forced Transformer	RAVDESS	neutral, calm, happy, sad, angry, fearful, disgusted, and surprised
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**Remark**

Table 3 compares these methods, and Figure 2 compares their performances. Baltrusaitis *et al.* (2019) think that multimodal machine learning faces five significant challenges: (1) multimodal representation, (2) multimodal translation, (3) multimodal alignment, (4) multimodal fusion, and (5) multimodal co-learning. They summarise the state-of-art studies on each major challenge one by one. Multimodal machine learning is theoretically applicable to MSA tasks because the two face common challenges. In the future, it is worth thinking of whether or not there is a general multimodal machine learning algorithm that can do MSA. Besides, there are still many challenges with multimodal pre-training models in the era of deep learning. For example, compared with the NLP data set, the image and video data sets are smaller, but a pretraining model of this kind requires a massive amount of data. And the audio and video training data are different from the text. Audio and video have timing problems. According to a fixed time length, splitting the training data causes the training data to lack logical meaning. Also, the training costs are high.



Source: This study.

Figure 2: Performance comparison of various deep learning-based methods for dynamic MSA.

## MSA IN CONVERSATION

This section briefs MSA in conversations (a new and very challenging task). It aims to detect the sentimental state of speakers and track their sentimental changes during the dialogue. Some commonly used dataset for MSA in conversations are IEMOCAP (<https://sail.usc.edu/iemocap/>), SEMAINE (<https://semaine-db.eu/>), DailyDialog (<http://yanran.li/dailydialog>), sentimentLines (<http://doraemon.iis.sinica.edu.tw/sentimentlines/index.html>), EmoContext (<https://www.humanizing-ai.com/emocontext.html>), MELD (<https://affective-meld.github.io/>) and MEISD (<http://creativecommons.org/licenses/by/4.0/>).

### CNN+LSTM-Based Method

To model the interactive information accurately, Zhang *et al.* (2020c) propose a comprehensive framework for MSA in multi-party conversations, called a Quantum-like Multimodal Network. Specifically, they firstly use a density matrix-based CNN to extract text and image features from conversations. Then, they input these features into an LSTM. Finally, they use the softmax function to obtain the result of SA. Their experiments show that their method significantly outperforms various baselines. Compared with LSTM, on the IEMOCAP and MELD data sets, the accuracy of their model is increased by 3.61% and 6.76%, respectively. The performance of their model largely depends on the representation quality of the density matrix. So, in the future, it is worth studying to capture more accurately interactive information between speakers.

### Memory Network-Based Method

To recognize utterance-level emotions in dyadic conversational videos, Hazarika *et al.* (2018) consider the contextual relation and dependency relation between discourses and use the dialogue memory network to solve the classification problem of video sentiment in conversation. They propose an architecture, termed CMN, for emotion detection in a dyadic conversation that considers utterance histories of both the speaker to model emotional dynamics. They perform experiments on the IEMOCAP dataset (Busso *et al.*, 2008). Their model is good at recognizing positive emotions, and when recognizing happiness and anger, its accuracy rates are 81.75% and 89.88%, respectively.

### RNN-Based Method

To leverage and capture the context of the conversation through all modalities, the dependency between the listener(s) and speaker emotional states, and the relevance and relationship between the available modalities, Shenoy and Sardana (2020) propose an end-to-end RNN based method for MSA in conversion. It considers the conversation context through all modalities, the dependency between the listener(s) and speaker emotional states, and the relevance and relationship between the available modalities. Their experiments show that their method outperforms the state-of-art method on a benchmark dataset in terms of accuracy, regression, and F1-score.

To capture the interlocutor state and contextual state between the utterances, Huddar, Sannakki, and Rajpurohit (2021a) propose a method based on RNN to obtain interlocutor state and context state between utterances. This article first extracts features from the text, sound, and visual features. An attention-based pairing technique is used to extract the context between utterances and to understand the relationship between forms and their importance before fusion. Their experiments show three standard data sets, IEMOCAP, CMU-MOSEI, and CMUMOSI, and their model is better than the standard baseline.

### Remark

SA in dialogues plays a critical role in dialogue data analysis (Wang *et al.*, 2020a). Although the single modal feature extraction methods employed by most researchers are similar, information fusion mechanisms are different, which can be summarised as feature-level fusion, decision-level fusion, and hybrid fusion mechanisms based on the two.

Unlike ordinary MSA tasks, MSA in conversation pays more attention to the interaction between different modalities. Here the interaction means the mutual influence of dialogue parties and joint representation and decision fusion between different modal data in a conversation. Inter-discourse interaction refers to the mutual influence caused by repeated interaction between dialogue parties.

For a human-machine dialogue system, since it is unavoidable that human has emotions in dialogue with the system, the system has to deal with these emotions. So, how to enable computers to understand and express sentiments in conversation is a new challenge in the fields of human-computer dialogue and SA.

## CONCLUSION

MSA is a critical issue in the natural language process. This paper surveys various MSA methods based on DL (including CNN, RNN, LSTM, Transformer, and Attention Machine). In particular, we analyze their advantages and disadvantages and point out the avenue for their improvement in the future. Besides, we review the work on MSA in conversation.

The audio and video data can reflect the user's tone. Hence, many researchers use speech data to help SA. One vital challenge in automatic speech SA is how to learn robust and discriminative representations for sentiment inferring. Besides, the use of computer vision to do SA is a relatively new topic. Its main task is to recognize and model sentiment information observed through faces, bodies, or gestures. The general direction of future work on MSA is data representation learning, feature extraction, and information fusion. The importance of the weight distribution of various modal data is also a topic worthy of

further discussion. In particular, what deserves MSA researchers focus on is the pre-trained models such as BERT and GPT-3. They are powerful, new paradigms of NLP and applicable to MSA. In (Macary *et al.*, 2021), the experimental pre-training model is used for speech emotion recognition.

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## Navigational Guidance – A Deep Learning Approach

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### ABSTRACT

The useful navigation guidance is favorable to considerably reducing navigation time. The navigation problems involved with multiple destinations are formulated as the Directed Steiner Tree (DST) problems over directed graphs. In this paper, we propose a deep learning (to be exact, graph neural networks) based approach to tackle the DST problem in a supervised manner. Experiments are conducted to evaluate the proposed approach, and the results suggest that our approach can effectively solve the DST problems. In particular, the accuracy of the network model can reach 95.04% or even higher.

*Keywords:* Navigation guidance, directed Steiner Tree, graph neural network.

### INTRODUCTION

The processes of navigation are omnipresent in modern society. Since most people are reluctant to spend enormous time on the way to the destinations, providing practical navigation guidance is desirable. Good guidance can save substantial time. Therefore it could benefit people by certain occupations, such as delivery men or Uber drivers to whom time cost is crucial. Speedy finishing orders bring more orders and income consequently. On the other hand, excessive steering would incur delay or even retreat in the process of navigation. Furthermore, Uber drivers might not prefer to take an order when seeing the route is tortuous. In terms of the Web, an appropriate path is beneficial for both surfers and website owners by reducing the searching time to retrieve information and promoting the advertisement of websites, respectively.

Providing effective navigation guidance is a challenging task due to the scale and complexity of applications in reality (e.g., city maps and websites) (Yen & Wan, 2010). Worse still, such a task can be further complicated by the diversity and multiplicity of destinations. It is straightforward to use those shortest path algorithms (e.g., Dijkstra algorithm (Dijkstra, 1959)) to acquire the optimal paths for single destination problems, yet the problems become tricky with multiple destinations involved. Basically, randomly exploring multiple destinations could be cumbersome. The major issue then is how to find optimal paths for reaching multiple destinations with minimum navigation time. Therefore, this paper focuses on an approach to analyze the problem as the Directed Steiner Tree (DST) problem (Charikar *et al.*, 1999), an NP-hard combinatorial optimization (CO) problem (Karp, 1972). Recently, deep learning has been proved to be suited for solving various CO problems (Bengio *et al.*, 2021; Mazyavkina *et al.*, 2021; Vesselinova *et al.*, 2020). In general, NP-hard problems on graphs can be formulated as sequential decision-making tasks due to their highly structured property (Joshi *et al.*, 2019), and deep learning can automatically detect useful patterns in the data. Hence, deep learning-based approaches are good candidates to be adopted for approximately solving those CO problems.

In this paper, we propose a deep learning-based approach to solve DST problems. Then the solutions can be served as optimal navigation guidance. The core of our model is Graph Attention Network (GAT) that proposed by Veličković *et al.* (2017). We demonstrate our approach through simulations, and the experiments indicate that the approach can effectively address DST problems and efficiently generate optimal navigation guidance.

The remainder of this paper is organized as follows. A survey of related work is given in section 2. A problem modeling is introduced in section 3. Subsequently, the deep learning (neural graph networks, to be exact) based approach is described in section 4. The numerical experiments are conducted in section 5 to evaluate the performance of the proposed approach. Finally, the paper concludes with a summary in section 6.

### LITERATURE REVIEW

#### Navigation and Guidance

In a broad sense, navigation can refer to any study that involves the determination of position and direction (Hofmann-Wellenhof *et al.*, 2003). Most literature on navigation studied position systems of vehicles with multi-sensors (Syed *et al.*, 2008; Jost *et al.*, 2014; Wang *et al.*, 2020; Rose *et al.*, 2014; Jiang *et al.*, 2017; Vu *et al.*, 2012), or navigation in networking (Win *et al.*, 2011), whereas the direction aspect is the thing that draws our attention.

Some studies focus on navigation for people. Niu *et al.* (2019) fuse the information of two foot-mounted systems to achieve more robust and reliable performance; Renaudin *et al.* (2017) conduct an original transdisciplinary study of the underlying reasons about no universal solution of a navigation system; Mancini *et al.* (2015) propose a safe point-to-point navigation for impaired people owing to high-detailed road graphs; Patil *et al.* (2011) present a novel approach to guide agents towards desired goals using navigation fields. Besides humankind, navigation for mobile robots is one of the popular fields. Shi *et al.* (2007)

developed a novel fuzzy behavioral scheme for navigating an unmanned helicopter in cluttered 3-D spaces; Gabriely and Rimon (2008) introduce a notion of competitiveness suitable for online mobile robot navigation in general planar environments; Liu *et al.* (2021) present a self-improving lifelong learning framework for a mobile robot navigating in different environments that improves a mobile robot's navigation behavior purely based on its own experience.

It is significant to recommend an appropriate path, i.e., guidance, for navigation. This is because not only distinct paths might enormously differ in time, but also a poor path would cause troubles (e.g., collision). Votion and Cao (2019) develop navigation algorithms for cooperative unmanned vehicles in cost-map environments. Loizou (2017) maps an obstacle-cluttered environment to a trivial domain, reducing the navigation task to connecting the images of the initial and destination configurations by a straight line. Devaurs *et al.* (2016) develop sampling-based algorithms for path planning in cost space, efficiently solving high-dimensional search space. Muralidharan and Mostofi (2019) focus on a general path planning problem of a robot on a graph with edge costs, where each node has a Boolean value denoting success or failure with a given probability.

### Combinatorial Optimization (CO) and Graph Neural Network (GNN)

This study aims at investigating the optimal navigation guidance in general graph structure (Gross & Yellen, 2006) environments, e.g., city maps and websites. Yen and Wan (2010) report positive results that support the use of the web navigation guidance for one destination web page. However, the information of interest was often scattered on several web pages. It is, therefore, desirable that the optimal navigation guidance could handle the destinations with diversity and multiplicity. Thus, the navigation problem can be formulated as a Directed Steiner Tree (DST) problem (Karp, 1972). Deep learning algorithms have been used to approximate for solving CO problems (Smith, 1999; Bengio *et al.*, 2021). Besides, owing to the graph structure, Graph Neural Networks (GNN), deep learning-based methods for graph data, are more suitable for solving them.

Khalil *et al.* (2017) first consider the graph structure and encode problem instances using a graph embedding model (Dai *et al.*, 2016). Nowak *et al.* (2017) train a Graph Neural Network (GNN) in a non-autoregressive and supervised manner to output a TSP tour (Wu *et al.*, 2016). Joshi *et al.* (2019) leverage different Graph Convolution Networks (Bresson & Laurent, 2017) and improve the performance on top of Nowak *et al.*'s work. Kool *et al.* (2021) further integrate Joshi *et al.*'s model with dynamic programming (DP) to Solve Vehicle Routing Problems (VRP). Cappart *et al.* (2021a) train a GAT-based model to learn a policy for Markov decision process (MDP) problems using reinforcement learning and constraint programming.

Along with those work mainly on TSP and VRP, Barrett *et al.* (2020) utilize the framework of Dai *et al.* on the Maximum Clique (MC) problem. Li *et al.* (2018) integrate a GCN with a guided tree-search in a supervised setting for Maximal Independent Set (MIS), Minimum Vertex Cover (MVC), and MC problems. From the perspective of approximation ratio, Sato *et al.* (2019) first theoretically demonstrate approximation ratios of using GNN for MVC. For more surveys of machine learning for combinatorial optimization in general, please refer to (Bengio *et al.*, 2021; Mazyavkina *et al.*, 2021; Vesselinova *et al.*, 2020; Cappart *et al.*, 2021b).

To our knowledge, this work is the first to train Graph Neural Network (GNN) models with the goal of solving DST problems. The closest work to ours might be Joshi *et al.* (2019) and Li *et al.* (2018), both using GNN models to solve different CO problems by supervised learning, but their models are not suited for solving our problems.

## PROBLEM DESCRIPTION AND MODELLING

The structure of a map is represented as a directed graph, where each node denotes a site (e.g., a building, a recreation facility, or a residential spot), and each arc represents a road (i.e., path, arc, or edge).

### Graph Structure and Traversal

The graph  $G = (V, E, w)$  is defined as follows:

*Nodes:*  $V = \{v_1, v_2, \dots, v_n\}$ , where  $v_i$  denotes a site or a web page,  $i=1, 2, \dots, n$ ;

*Arcs (Arcs):*  $E = \{e_{ij} = [v_i, v_j] \text{ or } (i, j) \mid \text{A road or a hyperlink exists from node } i \text{ to node } j\}$ ;

*Weights:*  $w: E \rightarrow R^+$  is the edge-associated weight that reflects the road length or loading time of a web page.

In the above definition of  $G$ , the length of  $e_{ij}$  is the same as  $e_{ji}$  only if it is a bidirectional road, as far as the web is concerned, the loading time will vary as it is related to the size of the next desired page. Traffic and network condition are not considered in this paper.

A simple example with identical weights in Figure 1 is presented to illustrate the traversal process. The preferences of navigation can be diversified that there could be multiple destination nodes, especially equal or greater than 3. As shown in Figure 1, it is non-trivial to determine an optimal path from the root node  $A$  to the destination nodes  $G, J$ , and  $K$ .

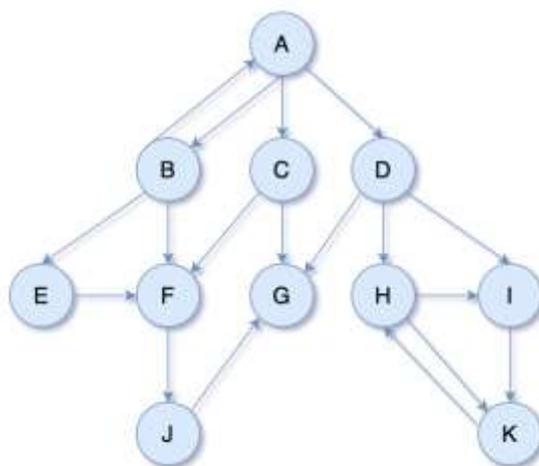


Figure 1: Single source to multiple destinations.

### Steiner Problem in Directed Graph

The Directed Steiner Tree (DST) problem is defined as follows: Given a directed graph  $G = (V, E, w)$  with  $n$  nodes and  $m$  arcs, a node  $r$  called root and a set  $X$  of  $k$  nodes called terminals (destinations) and non-negative weights  $w$  associated with arcs, the DST problem is to find a minimum cost directed tree rooted at  $r$  spanning all destinations.

In fact, the DST problem has been widely studied in the literature, whereas no polynomial approximation algorithm achieves a constant ratio contrary to the undirected version (Watel & Weisser, 2016). One of the renowned heuristic methods for DST problem is proposed by Charikar *et al.* (1999), a greedy non-trivial algorithm achieving  $l(l-1)k^{\frac{1}{l}}$  factor based on Zelikovsky's  $l$ -restricted Steiner tree (Zelikovsky, 1997), where  $n$  is the number of nodes in the graph,  $k$  is the number of destinations, and  $l$  denotes every leaf node being at most  $l$  edges away from the root node. Due to the high time complexity of Charikar *et al.*'s algorithm, Hsieh *et al.* (2006) developed a faster approximation algorithm for directed Steiner trees based on it. Takahashi and Matsuyama (1980) proposed a straightforward greedy approach to find the shortest destination from the "selected tree." Since Charikar *et al.*'s algorithm, the state-of-the-art polynomial-time approximation algorithm for the DST problem is presented by Grandoni *et al.* (2019). Linear programming-based methods are also widely applied to DST problems, such as (Rothvoß, 2011). For the exact solution of the DST problem, the directed version of the original Dreyfus-Wagner algorithm (Dreyfus & Wagner, 1972), a dynamic programming algorithm, can be used to obtain it in exponential time.

### DEEP LEARNING APPROACH

Both the approximation and exact algorithms have intrinsic limitations. Takahashi-Matsuyama algorithm (Takahashi & Matsuyama, 1980) is fast, but the performance (solution quality) is not satisfactory sometimes; the performance of the Charikar algorithm (Charikar *et al.*, 1999) is acceptable but at the sacrifice of time and space. Even though the approximation ratio of the Grandoni algorithm (Grandoni *et al.*, 2019) is the best to date, its computation time of it remains an issue.

In light of two essential requirements for real-time and minimum cost, we propose a deep learning approach based on Graph Attention Network to provide navigation guidance for multi-destination problems. The guidance data (i.e., optimal paths) is generated from the directed variant of the Dreyfus-Wagner algorithm (Dreyfus & Wagner, 1972). Then path information as well as graph information, including node features and edges, are fed into the neural network model to train. The output of each node denotes the probabilities of nodes that belong to the optimal path. After adequate training, the neural network can provide identical navigation guidance paths with those generated by the Dreyfus-Wagner algorithm given unseen destination sets, which reflects good generalization.

In terms of neural network architecture, since the graph is a type of non-Euclidean structure data, unlike image, video, text, etc. those can be represented in the Euclidean space, it is challenging and unsuitable to adopt Multilayer Perceptron (MLP) or convolution neural networks (CNNs) (LeCun & Bengio, 1995). Recently, many studies have extended deep learning on graph data called graph neural networks (GNNs) and proposed various network architectures exclusively for graphs (Wu *et al.*, 2020). Among them, we do not take spectral-based convolutional graph neural networks (ConvGNNs) into consideration, owing to their undirected and fixed graph scope (Wu *et al.*, 2020). Graph Attention Network (GAT) (Velickovic *et al.*, 2017), one of the spatial-based ConvGNNs, is suitable for our problem. GAT assumes contributions of neighbor nodes to the central node are neither identical like GraphSage (Hamilton *et al.*, 2017) nor pre-determined like GCN (Kipf & Welling, 2016). In fact, it accords with the logic of the aforementioned directed Dreyfus-Wagner algorithm. Each neighbor node has a disparate impact on the central node as the weight of edges is different when finding the shortest path. Furthermore, to emphasize the influence of weights, a GAT layer is accompanied by a linear layer that is fed in node features only. Then their outputs are passed through a Batch Normalization layer and followed by the ReLU activation function. We construct several layers to repeat such a process,

guarantee enough parameters and make it fully trained. Since our problem is a binary node classification problem that nodes within the guidance are labeled as 1 while others 0, the final output layer should apply a sigmoid function to bound it in the interval  $[0, 1]$ . The whole neural network architecture is presented as follows (Figure 2).

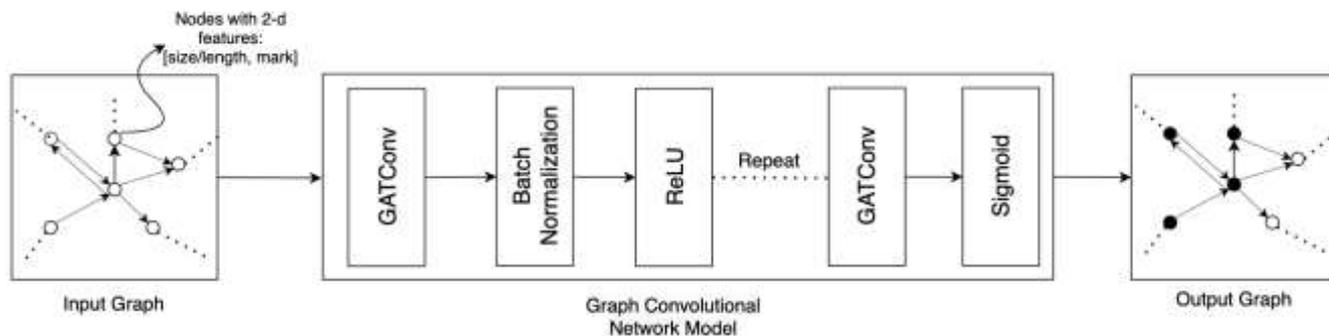


Figure 2: The model architecture.

To sum up, we feed the paths generated from an exact solution of the Directed Steiner Tree problem as well as corresponding graph data into GAT networks to pre-train, thus achieving real-time and minimum cost navigation guidance to suggest. Please refer to Section 5.2 for more details about the proposed model.

### EXPERIMENT RESULTS AND DISCUSSION

In this section, numerical experiments are conducted to assess the performance of the proposed deep learning approach for navigation guidance in various scenarios. For node classification problems, the common metric is accuracy. However, the class distribution of the dataset for navigation guidance problems is uneven, i.e., the number of nodes on the optimal paths is relatively small. Besides, if one node is misclassified in the graph, either making the path impassable or superfluous, the path result is not acceptable. Hence, a more rigorous metric is required as misclassification of even one node would influence the guidance path. Therefore, instead of from the perspective of a single node, we define that for each data sample that it is classified as correct only if all nodes in the graph are labeled correctly. The metric referred to as “path accuracy” is the rate of the number of correct data samples against the total number of data sets.

#### Graph Generation

The graph, represented by  $G = (V, E, w)$  as described in section 3.1, is generated from the following procedure:

- (1) Set the number of nodes  $n = |V|$ .
- (2) Randomly generate outdegree and point-to-neighbors for each node. The distribution of outdegree can follow power law to satisfy characteristics of certain graphs, e.g., the web (Broder *et al.*, 2000; Pennock *et al.*, 2002), BA graphs (Albert & Barabási, 2002), or random graph theory (Erdős & Rényi, 2011).
- (3) Randomly assign the weights of edges from a Gaussian distribution.
- (4) Randomly select  $k$  destinations that can be reached from the root node  $r$ .

After the graph generation is complete, the directed Dreyfus-Wagner algorithm (Dreyfus & Wagner, 1972) can be used to generate optimal paths according to pairs of root nodes and destinations.

#### Neural Network Configuration

Based on the network architecture described in section 4, there are a total of 12 layers of GAT and Linear including input layer and output layer, followed by Batch Normalization (BN) and ReLU sequentially except the output layer. Thus, there are 11 BN layers and 11 ReLU functions in total, as well as 1 sigmoid function at the final output layer. For each GAT layer, the hidden channel and head are 128 and 4, adding up to 512 parameters. In the training stage, we set batch size as 32, chose Adagrad as the optimizer, and the learning rate as 0.01. Adagrad is suited for uneven distribution problems, and these hyperparameters are obtained through trials and experience. The loss function is binary cross-entropy. All experiments are carried out with a single GPU NVIDIA Tesla P100-PCIE 16G and programmed in Python.

#### Experiments

We first study on a fixed graph, i.e., the graph scale, node features, edge connection, and edge weights are pinned down, and explore the influence of destination number on metric path accuracy. The initial node number and the destination number are 100 and 3, respectively.

To start with, we set destination number  $k$  as a constant number 3 as initial. Randomly select three destinations in the fixed graph except for the root node, and generate corresponding optimal paths. Totally we generate 40000 such data samples and split them as training dataset (70%) and test dataset (30%). The training dataset is approximately 18% of all permutations of 3 destinations,

i.e.  $C_3^{99} = 156849$ . It is reasonable that more training data would make the neural network learn better, but we found 18% of all possible permutations is enough to train a workable model. The loss and path accuracy curves are as follows. See the figures below.

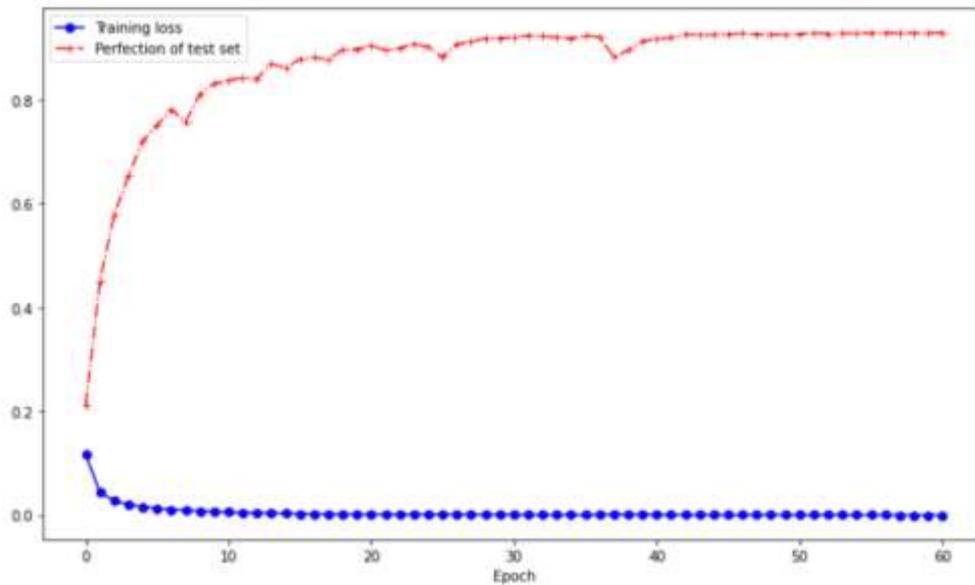


Figure 3: Path accuracy of the test set and training loss.

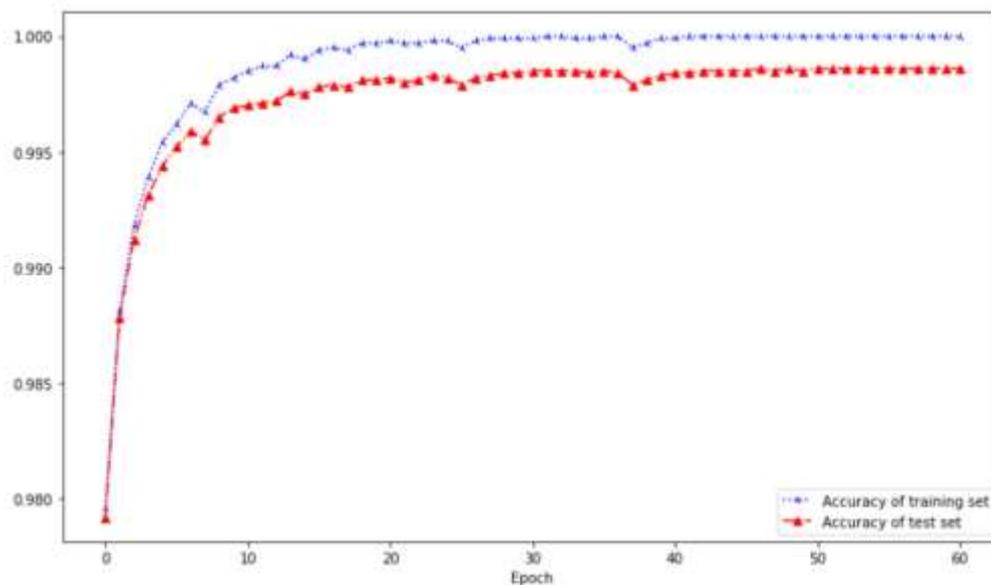


Figure 4: Path accuracy of training and test set.

As shown in Figures 3 and 4, the training loss drops to almost 0.0000, and the accuracy of the training set reaches 99.99% respectively after enough epochs. It implicates that the neural network has made full use of the training dataset. For the generalization, the path accuracy, the metric we pay attention to, of the test dataset is around 95.04% finally.

Then, we try to add nodes to a graph to imitate the growing process of the graph, e.g., new web pages are created in a website or road segments are expanding. As revealed by our experiments, the adding step of from 10% to 50% of the original number of nodes does not affect re-training and even boosts the former final path accuracy. In the case of 20%, the eventual path accuracy increases to 96.7% when the total node of a graph increases to 200. We can expand it to the scale of 1000 smoothly, and the final path accuracy is 98.10%.

Table 1: Experiment results when the graphs are growing.

Situation	Scale $n$	Destination $k$	Path Accuracy
The Basic Graph	100	3	95.04%
Addition	200	3	96.7%
Addition	1000	3	98.10%

## CONCLUSION

In this paper, we introduce a deep learning-based approach for approximately solving the Directed Steiner Tree problems using Graph Attention Networks via a supervised and no-autoregressive manner. Our approach trains a network model to predict the probability of each node whether it belongs to the optimal solution. A rigorous metric beyond node classification accuracy, path accuracy, is adopted to evaluate the performances. The experiment results show that our approach can effectively solve the DST problems with good scalability, and it implies the potential to utilize Graph Neural Networks to solve Combinatorial Optimization problems over directed graphs.

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## Online Learning vs. Offline Learning in an MIS Course: Learning Outcomes, Readiness, and Suggestions for the Post-COVID-19 World

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### ABSTRACT

This study aims to compare learning outcomes and technology readiness in online versus offline learning and to find suggestions from the viewpoint of learners. Besides, this study also compares differences in students' perceptions among learning styles. The associations between several factors such as experience and gender, and learning preferences are also explored. A questionnaire was developed to gather data from students who enrolled in an MIS course during the middle of the COVID-19 pandemic. Around half of the students were assigned to study the topic 'using MS Excel basics' in offline sessions, whereas the rest were assigned to learn through recorded videos online. Responses from 44 students, together with their comments and suggestions, were used for data analysis. This study found that both online and offline delivery methods can improve students' cognitive processes according to the Revised Bloom's Taxonomy and their topic interest significantly. On-campus classes could significantly enhance students' class attendance intention, but online classes could not. The cognitive process of RBT in terms of evaluating MS Excel content and class attendance intention of online students were significantly lower than offline students. Students also felt that place, equipment, and software on-campus were more ready than online environments. This work provides guidelines for both lecturers and universities in choosing teaching methods for using basic tools after the COVID-19 situation pass, selecting proper course types, designing course activities, and providing sufficient supports for better online learning outcomes. Research gaps suggested by past studies are filled up in this study.

*Keywords:* Student perceptions, learning outcomes, online learning, face-to-face learning, COVID-19, MIS education.

### INTRODUCTION

The COVID-19 pandemic affects how people live and work in almost all sectors (Laili & Nashir, 2021; Nguyen *et al.*, 2020; Valentino *et al.*, 2021). Schools to universities are temporarily closed, according to the government announcements. Some of them have to limit 50% of total students at school sites for social distancing. Many of them have to apply alternative teaching-learning methods and tools such as e-learning and video conferencing to fully deliver courses online (Adnan & Anwar, 2020; Aguilera-Hermida, 2020; Akuratiya & Meddage, 2020; Bączek, Zagańczyk-Bączek, Szpringer, Jaroszyński, & Wożakowska-Kapłon, 2021; Nasution *et al.*, 2021; Valentino *et al.*, 2021). However, moving from an environment of traditional education to online or distance education could not happen easily overnight (Adnan & Anwar, 2020). Although the increase in the use of Information and Communication Technologies (ICT), particularly the Internet, leads to the growth of online learning (Yusuf *et al.*, 2021). The transition from offline learning to online learning in higher education could be considered a relatively new phenomenon for some countries (Julien & Dookwah, 2020). The rapid transformation during the pandemic generates several obstacles and challenges for all parties. Educators must upgrade their technological skills for teaching online in a very short time (Adnan & Anwar, 2020; Aguilera-Hermida, 2020; Laili & Nashir, 2021; Valentino *et al.*, 2021). Many of them consider online learning as a failure since it cannot properly transfer knowledge to students (Valentino *et al.*, 2021). Although many students are digital natives, some students show stress and anxiety related to learning, isolation, and loneliness (Aguilera-Hermida, 2020; Besser *et al.*, 2020). Some students lack confidence in using technology and encounter difficulty in maintaining their concentration on distance learning (Aguilera-Hermida, 2020; Besser *et al.*, 2020). Understanding these challenges and obstacles that students face in the transition to online learning can help ensure equal access to education (Besser *et al.*, 2020; Chisadza *et al.*, 2021). However, the benefits of education on economic development have been proven in the literature (Chisadza *et al.*, 2021). Educational institutions are thus inevitable to find appropriate content, an effective delivery system, and provide digital literacy training to their faculties for better learning outcomes (Adnan & Anwar, 2020).

Offline or face-to-face (F2F) learning relies on the presence of instructors to teach in a physical environment (classroom). It is also referred to as traditional learning or conventional education, in which learning is centered on lecturer paces (Anggrawan & Jihadil, 2018; Nasution *et al.*, 2021). Offline learning highly supports interactions among learners and educators. Students generally feel more comfortable and learn easier in a familiar, traditional classroom environment (Julien & Dookwah, 2020). Lecturers or instructors in a F2F setting can receive immediate feedbacks or responses about lessons, delivery, and learning experience from students (Hilton *et al.*, 2020). Online learning, on the contrary, is the use of the Internet to access learning materials, to interact with content, lecturers, and other students, to get support throughout the learning process, without requiring students to physically attend classes (Nasution *et al.*, 2021; Nieuwoudt, 2020). It could utilize various forms of multimedia, e.g.,

text, audio, graphics, animation, video, discussion boards, e-mail, and other forms for learning purposes (Anggrawan & Jihadil, 2018; Bencheva, 2010). Online learning has been promoted as being more cost-effective and convenient than traditional classroom environments, as well as giving opportunities for learners to continue their education (Bączek *et al.*, 2021; Bali & Liu, 2018). Students are attracted to online education because of its flexibility (Laili & Nashir, 2021; Nieuwoudt, 2020). Learners are also trained to be more responsible, creative, independent, and confident in online learning (Anggrawan & Jihadil, 2018; Laili & Nashir, 2021). Online learning can be synchronous or asynchronous. An online course may deliver materials online and meet synchronously regularly with educators and peers, e.g., in a chatroom, or deliver course synchronously via the Internet at a specific time via a specific medium, e.g., video conferencing. The latter type is sometimes called distance learning, in which students and lecturers can engage simultaneously. For an asynchronous online class, lecturers prepare materials such as recorded lectures, assignments, etc., and deliver them online. Then, students complete them at their own pace at a convenient time within a given timeframe (Aguilera-Hermida, 2020; Brown & Park, 2016; McFarland & Hamilton, 2005; Nieuwoudt, 2020). Online learning in this study is an asynchronous online class according to the last definition.

Although online learning has become a major alternative approach in teaching and learning processes during the COVID-19 pandemic (Aguilera-Hermida, 2020; Anggrawan & Jihadil, 2018), it remains at an early stage of development (Smart & Cappel, 2006). Furthermore, studies taking place in online environments are relatively recent (Young & Duncan, 2014). Online learning is also not easy to deal with as imagined (Laili & Nashir, 2021; Tratnik *et al.*, 2019). In online learning, the interaction between students and lecturers is mediated by technology, which the design of learning environments could affect learning outcomes (Aguilera-Hermida, 2020). Because the success of online learning depends on various factors including accessibility, the usage of appropriate methods, course content, and assessment criteria (Bączek *et al.*, 2021). Several things need to be thought and considered to implement online learning such as learning models, methods, strategies, learning outcomes, and so on (Laili & Nashir, 2021). Online learning also needs supportive online learning environments and facilities, for instance, hardware, software, and Internet access (Anggrawan & Jihadil, 2018; Laili & Nashir, 2021; Tratnik *et al.*, 2019). These support facilities are more complicated for developing countries that lack the digital infrastructure for the majority of the population (Chisadza *et al.*, 2021). Hence, offline or face-to-face learning may sometimes be appropriate. Besides, offline learning is carried out before the COVID-19 epidemic but is suspended after that (Valentino *et al.*, 2021). Although the duration of the pandemic is unknown, the government in many countries plans to reopen offline learning with strict health protocols after the situation is better (Nguyen *et al.*, 2020; Valentino *et al.*, 2021). Understanding students' perceptions, challenges, and preferences which learning types they like or are comfortable with most could help in the educators' decision to go back to conventional learning or continue online learning after lockdown (Aguilera-Hermida, 2020; Akuratiya & Meddage, 2020; Paechter & Maier, 2010).

Offline learning and online learning have similarities and differences (Julien & Dookwah, 2020). For example, online learning tends to focus on the interaction of learning, whereas offline learning is more likely to emphasize the interaction of people (Anggrawan & Jihadil, 2018). Universities continue to integrate various forms of learning (Hilton *et al.*, 2020). But a few recent studies have investigated challenges and opportunities associated with online learning during pandemics (Adnan & Anwar, 2020). Studies comparing online and offline learning before the COVID-19 pandemic have yielded inconsistent results. Some studies indicate higher student satisfaction in offline learning, while some works show no significant differences between the two delivery formats (Tratnik *et al.*, 2019). Hence, the current situation is the right time to explore student perceptions of learning, to evaluate methods used by lecturers, and provide an overview and recommendations on future learning processes and improvements (Hilton *et al.*, 2020; Keller & Karau, 2013; Nasution *et al.*, 2021; Smart & Cappel, 2006). For research gaps, the comparison of online or offline learning regarding which is the right format in the new normal period, the gender effects on student perceptions, the effects of prior experience, current experiences, and opinions of students on learning, the problem related to technological infrastructure or technology readiness, students' topic interest development, student performance, the attrition rates or class attendance of each learning method, best online practices or the quality of online learning, the effects of learning types (online, offline) on the learning process, the impact of learning delivery method on skills-based learning are suggested to be further explored to improve learning success (Adnan & Anwar, 2020; Alsaaty *et al.*, 2016; Bali & Liu, 2018; Callister & Love, 2016; Hilton *et al.*, 2020; Kaushik & Agrawal, 2021; Kinlaw *et al.*, 2012; Nieuwoudt, 2020; Paechter & Maier, 2010; Shakourzadeh & Izadpanah, 2020; Swarat, 2008; Valentino *et al.*, 2021). Past research also guides lecturers to evaluate students' traits and learning styles, determine students' learning needs, examine the role of student characteristics in class attendance, and plan to deliver courses that match their styles or characteristics and preferences (Kinlaw *et al.*, 2012; Smart & Cappel, 2006; Smith *et al.*, 2015; Tratnik *et al.*, 2019). Lu *et al.* (2003) also state that there are a few studies involving learning styles in online business courses. No studies to date have explored these gaps simultaneously.

As the foregoing reveals, the current study tries to examine student perceptions (perceived learning outcomes, perceived technology readiness), the differences in these perceptions among student learning styles and delivery formats, and students' online preferences. Data from an introductory MIS course, which is a core course for undergraduate students in the business program, in the part of using MS Excel that had both online and offline delivery formats is used. The study aims to address research questions as follows: 1) Are students perceived learning outcomes in terms of the cognitive process dimensions of Revised Bloom's taxonomy (RBT), topic interest, and class attendance improved after completing the MS Excel part in any course delivery formats? 2) In what way do students evaluating learning outcomes, performance, and technology readiness for offline learning differ from online learning? 3) Do any differences exist between student learning styles concerning their perceived learning outcomes and performance? 4) Are experience, gender, student learning style, and technology readiness related to students' online preference? 5) For what courses or course types do students prefer online learning? 6) What are the

best online practices suggested by students? The RBT has been used for various purposes in education, such as evaluating alignment between curriculum, teaching, and assessment, planning teaching activities and lessons, designing assessment, and analyzing students' performance in the past (Radmehr & Drake, 2019). However, to date, it has not been applied in comparing online and offline settings in MIS education.

### LITERATURE REVIEW

McFarland and Hamilton (2005) carefully controlled and compared student satisfaction between online and traditional classes, preliminarily introduced possible drivers to enhance the performance and satisfaction of students in online sections. The results also confirmed past research about insignificant differences in student performance between online and traditional classrooms. Paechter and Maier (2010) explore student experience regarding the favorable aspects of e-learning and face-to-face learning. Findings indicated that they appreciated online learning in terms of a clear and coherent structure of learning materials, which supported self-regulated learning. Face-to-face learning was preferred due to communication purposes in which a shared understanding has to be established. Liu (2010) compared instructional differences between F2F and e-learning methods in goal-oriented students who faced the competitive entrance exam of graduate schools in Taiwan. The results revealed that the e-learning method offered higher learning effectiveness and yielded more satisfaction on learning materials and environments than F2F learning. Nevertheless, there was no significant difference in the satisfaction of instructors or teachers between the two modules. Dziuban and Moskal (2011) compared online, blended, and F2F courses. Findings showed that factors across different class formats were identical. Thus, the authors concluded that the course modality did not affect end-of-course evaluations. Schwartz (2012) investigated F2F versus online sections of accounting classes. The results indicated a lower level of achievement in online sections. Murdock *et al.* (2012) explored students' skill acquisition in on-campus and online environments of an introductory counseling skills course. The results presented no significant differences in either course format related to students' basic counseling skill acquisition.

Young and Duncan (2014) compared student ratings in online and F2F courses in higher education. Findings showed that offline courses were evaluated significantly higher than online courses in several aspects, including communication, faculty-student interaction, grading, instructional methods, and course outcomes. On the contrary, student effort was rated significantly higher for online than F2F courses. Comparing the same courses with the same instructors also revealed similar results. Students were more satisfied with traditional learning compared to online learning. Smith *et al.* (2015) examined differences in the learning levels and perceived efficiency between online and F2F courses for graduate students. The results pointed out that students in both groups gained the same levels of learning. However, they perceived a significant difference in their learning efficacy. Online instructional modality received more favorable in perceived learning efficiency. Biel and Brame (2016) reviewed the literature concerning the effectiveness of online instruction in biology courses. Of eight large-scale studies, the results from two studies found that students in F2F classes outperformed students in online classes, while three studies showed no significant difference. For eight small-scale studies, six of them also showed no significant difference in student performance between the two class formats, but two of them found superior performance in online sections than F2F sections. Callister and Love (2016) compared learning outcomes of online versus F2F skill-based (negotiation) courses. Findings indicated that F2F learners gained higher negotiation outcomes than online learners. Brown and Park (2016) conducted longitudinal research to explore research self-efficacy and retention between online instruction and F2F instruction. The results showed that students' knowledge and research self-efficacy increased between pretest and posttest. This knowledge and research self-efficacy remained significantly increased after a one-year follow-up later. Nevertheless, there was no significant difference between online and F2F students, which means students gained and maintained their research method knowledge regardless of which learning platforms were utilized.

Bali and Liu (2018) examined student perceptions in the context of social presence, social interaction, and satisfaction between online versus F2F learning in Indonesia Open University, Taiwan branch. Findings indicated a higher learning perception in F2F learning than online learning in all aspects, but there was no statistically significant difference in learning preferences among students at different levels. Anggrawan and Jihadil (2018) tried to find an answer to the question, an online learning/ e-learning truly replace F2F learning in the cognitive area? Findings revealed that online learning could substitute traditional learning in the cognitive area. The results were based on the algorithm and programming instructional at STMIK Bumigora tertiary institution. Stark (2019) intended to compare motivations and learning strategies between online and F2F students. The results pointed out that although online students reported lower motivations compared to F2F students, these motivations strongly correlated with their performance rather than learning strategies, especially for online courses. Tratnik *et al.* (2019) compared student satisfaction in an online versus conventional Business English course. Findings revealed a significant difference in the levels of student satisfaction among the two learning formats. Face-to-face students earned more satisfaction with the course in several dimensions than their online counterparts.

Hilton *et al.* (2020) explored student perceptions and course satisfaction of online and F2F courses. The results indicated no significant differences in the analysis by gender and majors, but there were differences between the second-year and the fourth-year graduate students. Besides, more positive perceptions of online learning could be increased if students took more online courses. Thai *et al.* (2020) explored four learning environments that were face-to-face learning, fully e-learning, blended learning, and flipped classroom in terms of student performance in the Animal and Human Physiology course. Changes in perceived flexibility, intrinsic motivation, self-efficacy beliefs of students, and the interaction effects of these variables on learning performance were investigated. There was a significant positive differential effect on students' learning performance in the flipped classroom and blended learning settings, but there were no significant interaction effects regarding changes in perceived

flexibility, intrinsic motivation, and self-efficacy. There were significant differences between learning environments or conditions in students' perceived flexibility. Bourzgui *et al.* (2020) evaluated the effectiveness of blended learning compared to F2F learning and assessed student perceptions about blended learning. Findings pointed out that more than 50% of students attended lectures regularly, believed that course objectives were reached and well-defined, used an e-learning platform (Moodle), faced difficulty in studying materials online, and thought that interactive evaluation was not enough. They also believed that teaching should not be fully conducted online. Julien and Dookwah (2020) conducted action research regarding the experiences of undergraduate students in the transition from F2F to online learning. The results from the informal, structured interview and semi-structured questionnaire showed the possibility of online learning for instructional options and F2F learning for human interaction and mathematics-related courses. Adnan and Anwar (2020) examined the attitudes and perspectives of Pakistani higher education students toward compulsory digital and distance learning during COVID-19. Findings highlighted that online learning could not generate desired outcomes in underdeveloped countries since a vast majority of students were unable to access the Internet properly.

Aguilera-Hermida (2020) explored college students' adoption, use, and acceptance of emergency online learning because of COVID-19. The results showed the significant roles of attitude, motivation, self-efficacy, and technology usage in students' cognitive engagement and academic performance. However, students preferred F2F learning over online learning. Akuratiya and Meddage (2020) studied IT students' perceptions of online learning during the COVID-19 pandemic in Dehiwala, Sri Lanka. Findings revealed that more than 60% of participants had little or no experience with online learning before. More than 50% of them preferred blended learning and raised the challenges in online learning, including the reduction of interactions with teachers and peers, social isolation, and technical problems. Nevertheless, 82% of them agreed to combine online learning into their course in the future. Students also perceived online learning as effective as traditional learning because online learning was enjoyable, let students learn at their own pace and easy to access materials, and created active participation. The authors indicated the favorable perception of online learning among IT students. Besser *et al.* (2020) explored higher education students' adaptability to the COVID-19 pandemic, personality, and learning experiences. The results showed the negative reactions of students to the online condition, which became necessary due to the pandemic. Even so, students with adaptability to the pandemic showed more positive reactions across multiple indicators. Their personality traits were also associated with specific reactions to online learning through their learning adaptability. Schlenz *et al.* (2020) assessed students' and lecturers' perspectives on the transition to online learning due to COVID-19. Findings showed that 36.8% of students preferred F2F learning rather than pure online learning. Both students and lecturers were interested in keeping up with online courses in the future. Nieuwoudt (2020) investigated the relationship between students' online interaction and participation and their academic success as well as class attendance in both virtual classes (synchronous) and/or watching the recorded virtual classes (asynchronous). The results indicated the importance of class attendance, but it did not differ whether students attended classes synchronously or asynchronously. A significant relationship was supported between students' participation and interaction with an online learning system and their academic success.

Laili and Nashir (2021) explored higher education students' perceptions, supporting factors, and constraints regarding online learning of Intensive English class during the COVID-19 using the descriptive method. Findings showed both positive perceptions and negative perceptions of students in online learning. Positive perceptions were related to flexibility, whereas negative perceptions were difficult to practice conversation, fewer motivations, and constraints such as an unstable Internet signal, high cost of the Internet. Nasution *et al.* (2021) explored student perceptions of various learning experiences (F2F learning, blended learning, and online learning) and determined which learning type was preferred most by students. Findings confirmed that F2F learning was the most preferred choice by 78% of students, whereas 20% of students preferred blended learning and 2% of them chose online learning. Bączek *et al.* (2021) studied the perception of medical students regarding full online learning because of the COVID-19. Many respondents indicated the main advantages of online learning, which were the ability to stay at home (69%), continuous access to online materials (69%), learning at your own pace (64%), and comfortable surroundings (54%). The main disadvantages of e-learning were lack of interactions with patients (70%) and technical problems with IT equipment (54%). There was no significant difference between F2F and online learning concerning the ability of learning methods to improve knowledge, but online learning was considered significantly less effective than F2F learning in terms of increasing skills and social competencies. Medical students also evaluated themselves as less active in online learning compared to traditional learning. Nevertheless, many respondents (73%) rated e-learning as enjoyable. Chisadza *et al.* (2021) examined factors predicting students' performance after the transition from F2F to online learning due to the COVID-19 pandemic. Findings showed that students' performance in terms of the average assessment grades was driven by good Wi-Fi access. Lower academic performance was found in students who faced difficulty in transferring to online learning. Lower academic performance was also found in students who preferred self-study by reading class slides and notes more than students who preferred assisted study by joining live lectures or watching recorded lectures.

## BACKGROUND AND HYPOTHESIS DEVELOPMENT

### Learning Outcomes

#### *Revised bloom's taxonomy (RBT) and student performance*

Learning outcomes are competences that students aim to achieve. Competences may have different facets, such as factual and conceptual knowledge, methodical knowledge, social and personal competences, and media competence. In higher education, university students should acquire not only conceptual and methodical knowledge, but also social and personal competences e.g., competences in teamwork and self-regulation (Paechter & Maier, 2010). Online learning is crucial for higher education

institutions and is expected to improve students' learning outcomes (Laili & Nashir, 2021). Bloom's taxonomy (BT) is a widely used and well-known taxonomy for identifying, writing, or interpreting instructional objectives in educational settings (Kocakaya & Kotluk, 2016). Bloom's taxonomy, original version, defines six cognitive categories comprising of knowledge, comprehension, application, analysis, synthesis, and evaluation. It provides a basis for educators to classify learning levels in terms of expected outcomes for a given program. It is extended to the Revised Bloom's Taxonomy (RBT) with a knowledge dimension and minor adjustment in sequential order of six cognitive process dimensions (Lau *et al.*, 2018). The RBT also a classification of learning objectives, which are important as a common frame of reference to develop intended learning outcomes. It facilitates planning until assessing instruction and has been applied from pre-school education to higher education for all academic subjects (Kocakaya & Kotluk, 2016). Compared to the original Bloom's taxonomy, the RBT covers many aspects of assessment, which are not addressed in-depth as the previous version (Clark & Ernst, 2010). In addition, the study of Radmehr and Drake (2019) compares the RBT and some of the major theories and frameworks. Their results identify that the RBT is the most detailed, comprehensive, and flexible framework. Thus, it has the highest potential to explore teaching, learning, and assessment of mathematics than other theories and frameworks due to its broad approach, strengths in terms of two-dimensional structures that the overlaps of knowledge categories are allowed, and the rejection of strict hierarchy as the original BT.

For the RBT, nouns are used to show knowledge, whereas verbs are used to show the cognitive process. Four types of knowledge are factual, conceptual, procedural, and metacognitive knowledge, which could overlap each other. Factual knowledge is the terminology, specific details, and basic elements that students must know. Conceptual knowledge is the knowledge of interrelationships among the basic elements. It is also related to knowledge of classifications and categories, knowledge of principles and generalizations, knowledge of theories, models, and structures. Procedural knowledge is knowledge of subject-specific skills and algorithms, knowledge of subject-specific techniques and methods, knowledge of criteria for determining when to use appropriate procedures. Metacognitive knowledge is knowledge of cognition in general, awareness, and knowledge of one's cognition. It also refers to strategic knowledge, knowledge about cognitive tasks, and self-knowledge (Kocakaya & Kotluk, 2016; Radmehr & Drake, 2019). The cognitive process dimension of RBT consists of remembering, understanding, applying, analyzing, evaluating, and creating. These dimensions represent a continuum of increasing cognitive complexity, from lower-order thinking skills (remember) to higher-order thinking skills (create). 'Remember' is the lowest level of the cognitive process dimensions. It is defined as a cognitive process that requires students to identify and retrieve relevant knowledge from long-term memory. Recognizing and recalling are the sub-categories of remembering. 'Understand' allows students to construct meaning from instruction, including oral, written, and visual communications. The sub-categories of understanding are interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. In 'apply', students carry out or use a procedure that is normally hands-on. Executing and implementing are objectives or sub-categories of this category. 'Analyze' is the ability to break down materials and concepts into parts and specify how each part is related to each other. Analyzing is an extension of understanding. Three sub-categories of analyzing are differentiating, organizing, and deconstruction. 'Evaluate' allows students to make judgments based on a set of criteria or standards. Checking and critiquing are sub-categories of evaluating. 'Create' is the highest cognitive process dimension. It is the ability to put elements together and/ or reorganize elements to form new patterns or structures. Three sub-categories of creating are generating, planning, and producing (Clark & Ernst, 2010; Kocakaya & Kotluk, 2016; Lau *et al.*, 2018; Radmehr & Drake, 2019). The intersection between knowledge and cognitive process in the RBT is designed to support learning strategies and facilitate learning assessment (Lau *et al.*, 2018; Radmehr & Drake, 2019).

In addition to learning outcomes according to the RBT, Lu *et al.* (2003) mention that there has not been much research investigating the learning effectiveness of web course tools. Learning effectiveness could be evaluated through student performance and satisfaction. In their study, a lower number of errors on an achievement test after instruction indicates student performance, whereas drop rate, anxiety, and/ or frustration during the learning process show satisfaction. For online learning, the study of Nieuwoudt (2020) investigates the best predictor of final grades. The results show that the attendances of synchronous virtual class and recorded class significantly predict final grade in the Managing Your Study subject, but both variables are not significant predictors of final grades in the Studying Science subject. This study assesses student performance in both learning methods using the assignment score. Satisfaction in terms of topic interest and class attendance are explored and described further in the next section.

### **Topic interest**

Interest is the psychological state of engaging with classes of objects, events, or ideas over time (Swarat *et al.*, 2012). Interest is also defined as content-specific motivational characteristics, specific preference for particular subject areas, or a motivation to engage a topic or an activity (Swarat *et al.*, 2012). It is seen as a central to explain how people select and persist in processing certain types of information compared to others. Interest promotes motivation for learning and the long-term stage of information. It could result from the interaction of a learner and his/ her environment (Weber *et al.*, 2001). Interest is the driving force behind self-initiated learning behavior (Swarat, 2008). The positive effect of interest on learning, such as learning outcomes, achievements, or cognitive skill development, has been studied and documented in a wide range of learning situations (Swarat, 2008). Compared to learning based upon coercion, interest-based learning is an active state, which has personal meaning to learners. Therefore, researchers have tried to understand the impact of learning interest. Individuals are motivated to take part in activities they are interested in. However, interest is declined when they feel ill-prepared to complete a certain task (Weber *et al.*, 2001). Since interest plays an important role in promoting learning, educators should explore whether students show interest in the materials. Nevertheless, students' interests seem to decline over time. Educators thus have to provide materials that cater

to their interests. To do so, a firm understanding of what students are interested in is need. Knowing what topics are of high interest to learners can help educators in choosing topics to teach or help textbook writers or publishers in creating more attractive materials for students (Swarat, 2008).

Topic interest is a type of interest, which is seen as a relatively long-term preference for a certain topic or content (Weber *et al.*, 2001). It also refers to a learner's interest, which is evoked when a specific topic is presented. It is the extent to which materials are interesting enough for readers or learners to make them focus. Some past studies consider topic interest as a form of situational interest, while other studies view it as a form of individual interest. Because some learners may find the topic interesting because of their individual interests, but others who are not interested in the topic before. They think the topic is interesting due to situational interest factors such as novelty, anomaly, and unexpectedness afterward (Shakourzadeh & Izadpanah, 2020; Weber *et al.*, 2001). Both learners' well-established individual interest and their situational interests contribute to the increase of comprehension and learning. Several studies support the impact of high-interest topics on children's comprehension, inferencing, and retention (Shakourzadeh & Izadpanah, 2020). The study of Shakourzadeh and Izadpanah (2020) also indicates the importance of topic interest. There is a significant difference in students' perception (topic interest) between the textbook-assigned topics and self-selected topics. In the study of Swarat *et al.* (2012), the follow-up interviews of 30 students show that 19 of them believe topics affect students' perception of the interestingness of activity. Five of them also believe that activity affects their perception of the interestingness of the topic. Activities relating to experiment/ lab/ project and technology (computer/ Internet/ video) are main activities considered as interesting. However, activities relating to technology (computer/ Internet/ video) are also viewed as uninteresting as same as reading and writing activities, after the lecture. In sum, technology may not be preferred by all interviewees and its interestingness could be influenced by the content topic that is used.

### ***Class attendance intention***

Class attendance dramatically contributes to improving learning (Cortright *et al.*, 2011). It has been repeatedly shown to be related to student performances such as grades or test scores across a wide range of disciplines, from economics, social studies to biology (Cheung, 2009; Cortright *et al.*, 2011). There is also a common belief or conventional wisdom that academic success is linked to class attendance. Students who attend classes regularly generally achieve higher grades than those who do not attend classes on a regular basis (Cortright *et al.*, 2011; Nieuwoudt, 2020; Van Schalkwyk *et al.*, 2010). Students who attend classes more often obtain better grades (Cortright *et al.*, 2011). The empirical findings of Kwak *et al.* (2019) show that both lecture and tutorial attendance positively impact test scores. The results of Cheung (2009)'s study also revealed that students with high performance before attending the Wind Engineering course are associated with high-class attendance. They do not access online materials as much as the lower attendance students, but they generally gain better performance afterward. Their performance is also improved if they frequently access lecture materials online. Moreover, competing for academic commitment as a class attendance variable significantly correlate with total examination scores. Students who are absent frequently perform more poorly on course examinations compared to others (Grabe *et al.*, 2005). Highly motivated students attend classes more and succeed academically (Cortright *et al.*, 2011). Therefore, the reasons why students attend or do not attend classes have been examined from various perspectives (Van Schalkwyk *et al.*, 2010).

However, the relationship between class attendance and academic success is not necessarily linear. For example, a typical student's performance may not always affect by a few absences. In some cases, the relationship between class attendance and student performance is not significant but positive, and sometimes the correlation is relatively low. Nevertheless, students with high GPAs are more likely to attend class (Van Schalkwyk *et al.*, 2010). In online environments, students who view online materials perform better on course examinations. The frequency of absences is also associated with examination performance (Grabe *et al.*, 2005). Some studies found that webcasts or online materials encourage students to skip classes (Grabe *et al.*, 2005; Traphagan *et al.*, 2010). In the study of Traphagan *et al.* (2010), there is a difference in absence frequency between the webcast and non-webcast sections. Besides, there is a significant correlation between the frequency of accessing webcasts and online resources such as PowerPoint slides and the absence frequency in the webcast section, showing a negative relationship between online learning and class attendance. Accessing webcasts after missing a lecture is also the topmost reason for students to use webcasts. However, the webcast access could nullify the negative impact of absence behavior on student performance. More webcast viewing positively associates with higher performance. The study of Kinlaw *et al.* (2012) also supports that highly online resources used by lecturers lower the absence of students. The study of Nieuwoudt (2020) points out that there is a significant difference in final grades between students who do not attend any classes (synchronous virtual classes or asynchronous recorded virtual classes) and students who attend classes. Students who attend classes less than half of the classes poorly perform than students attending classes more.

### **Online Learning versus Offline Learning**

#### ***Learning outcomes***

Fourth-year pharmacy students have higher post-learning outcomes in a problem-based learning course than online students (Callister & Love, 2016). Young and Duncan (2014) compare ratings from students in F2F and online on matched courses. Course outcomes are significantly higher in F2F than in online settings. The study of Callister and Love (2016) compares the impact of class types on learning outcomes in the business deal negotiation exercise. Findings show a significant effect of class types on performance, in which students were learning on campus yield higher outcomes than those learning online. In the study of Bourzgui *et al.* (2020), 53.8% of students prefer F2F, but 61.1% of them support that online courses are effective in helping them understand course materials. The study of Bączek *et al.* (2021) shows no statistical difference between F2F and online

learning in terms of opinions regarding the ability of methods to improve knowledge. Nevertheless, e-learning is considered less effective than F2F learning in terms of enhancing skills and social competences. Literature reviews regarding online learning and student learning outcomes in the study of Murdock *et al.* (2012) indicate that, in general, research in higher education has found similar outcomes, e.g., performance, persistence, and learning outcomes for online and traditional F2F education situations. A past study also shows no statistically significant difference between students achieving learning objectives based on the course format (on-campus versus online settings) (Murdock *et al.*, 2012). There are no differences in learning outcomes in an introductory marketing class. Online learning formats provide equal learning outcomes across various subjects in the field of management, including qualitative management classes (Callister & Love, 2016).

Past research observes learning outcomes for F2F and online learners. Findings show that the learning outcomes of online learners are as effective as or better than learning outcomes for F2F learners (Chisadza *et al.*, 2021). Literature reviews in the study of Callister and Love (2016) point out that, in the studies examined since 2006, students in online courses perform slightly better than students in on-campus courses. The study of Paechter and Maier (2010) compares the suitability of learning methods in the view of students show that online sessions are significantly better than F2F sessions in the aspects of clarity and explicit structuring of the course and learning contents, the favorable cost-benefit ratio of effort and learning outcomes, fast feedback from tutors, easy and fast exchange of information and knowledge with other course participants, the flexibility of learning about time and place, flexibility about learning strategies and pace of learning, opportunities for exercising and applying one's knowledge, opportunities for monitoring one's learning outcomes, and acquisition of skills in self-regulated learning. On the contrary, F2F sessions are better for counseling and support for learning by the tutor, possibility to establish personal contact with the tutor, support for cooperative learning and group work with other course participants, possibility to establish positive social relations with other course participants, support for maintaining learning motivation, acquisition of skills in scientific work procedures, acquisition of conceptual knowledge in the subject matter, acquisition of skills in the application of one's knowledge and of using one's knowledge in practice, and acquisition of skills in communication and cooperation. In the study of Adnan and Anwar (2020), the majority (65.7%) of students perceive online learning as quite different from conventional learning. Most of them (71.4%) also agree that online learning is more motivating than F2F learning. However, 50.8% of students believe that it is not possible to effectively complete entire courses online only. The majority (78.6%) of students also feel that F2F contact with a lecturer is needed for any type of learning. Past studies show mixed results when comparing online and offline platforms in terms of learning outcomes such as course grades or GPA (Brown & Park, 2016). Callister and Love (2016) also conclude that literature reviews present mixed results. Some have found no differences, while others have found significant differences.

The study of Liu (2010) confirms that e-learning is superior to F2F learning in terms of overall learning effectiveness. In terms of student performance, a meta-analysis and review of online learning studies indicate that, on average, students taking all or a part of their class online perform better than those taking only F2F instruction (Schwartz, 2012). Ladyshevsky (2004) compares final grades of post-graduate students in nine units offered in both F2F and online modes of learning. Post-graduate students generally perform better in online mode. Besides, students completing units in both modes averagely have significantly higher grades than completing only online units. Literature reviews in the study of Callister and Love (2016) indicate that first-year nursing performs better on a theoretical examination in an online course, but there are no significant differences in their performance for a structured clinical exam. In an undergraduate course in Human Resource Management, online students generally outperform F2F students (Callister & Love, 2016). On the contrary, past research mentioned in the study of Akuratiya and Meddage (2020) indicates that e-learning is perceived as less effective than traditional classroom learning. The study of Murdock *et al.* (2012) shows a significant difference between final exam scores between online and F2F students. F2F students have higher final exam scores than online students. In the study of Schwartz (2012), Standard Learning Outcomes Assessment Test (SLOAT) Scores, course grades (GPA), and teaching evaluation of students from the aggregate courses of major subject areas in onsite mode are significantly higher compared to online mode. The study of Lu *et al.* (2003) specifies that there is a difference in student achievement because of delivery methods. Students in the traditional group have higher but not significant performance than students in the online group. A past study indicates that students taking distance education courses outperform students enrolling in traditional courses. Another research finds out that F2F students outperform online students in overall performance in terms of grade, but online students perform better in a knowledge-based examination (Smith *et al.*, 2015). There is research reporting no significant differences in performance levels between undergraduate students who complete online courses and students who complete F2F instruction. Another research also shows no significant difference in performance in terms of homework assignments between students enrolled online and F2F intermediate accounting courses (Smith *et al.*, 2015). The study of Thai *et al.* (2020) explores the learning performance of students after studying in different settings. Their results show no significant difference between e-learning and traditional learning. Past research shows no difference in quiz scores between online and F2F learners (Callister & Love, 2016). Literature reviews of empirical studies in the business school context show mixed results when comparing student performance, perceptions, and satisfaction between online learning and classroom learning (Cater III, Michel, & Varela, 2012). In sum, the results regarding student performance between online versus offline modes are mixed.

Considering class attendance, researchers have found that most students prefer attending lectures on-site over online for various reasons, for instance, classroom interactivity, in-person viewing of demonstrations, and better concentration (Traphagan *et al.*, 2010). However, some studies compare actual class attendance for classes with and without webcast or podcast access and have found insignificant differences between classes (Traphagan *et al.*, 2010).

### **Technology readiness**

readiness is recognized as one of the most important factors to achieve the successful implementation of e-learning in higher education. To build effective e-learning, the readiness of technology, the readiness of educational institutions, and the readiness of the community have to be prepared since they will later influence the quality of the e-learning program (Irene & Zuva, 2018). Irene and Zuva (2018) propose an e-readiness assessment model consisting of readiness in the aspects of people, technology, content, strategy, and institution. In terms of technology dimension, skills, software, and hardware are the main issues (Smith *et al.*, 2015). Psycharis (2005) specifies technology resources as criteria of e-learning readiness. Aydin and Tasci (2005) present an e-learning readiness model, which includes technology as one aspect. Technology refers to access to computers and the Internet, the ability to use computers and the Internet, and a positive attitude towards using technology. Lopes (2007) presents e-learning readiness that contains several dimensions: business, content, technology, culture, human resources, and financial. Technology is the degree of access to infrastructure. Darab and Montazer (2011) propose a framework for assessing e-learning readiness. Network and equipment are technological aspects relating to e-learning readiness. Akaslan and Law (2011) propose a model for measuring students' readiness for e-learning comprising of people, technology, content, and institution. Stability, software, and hardware are technological factors in readiness. Keramati *et al.* (2011) propose a conceptual model of factors influencing e-learning outcomes. Technical, as one of the readiness factors, and IT, as one of the e-learning factors, affect interaction, which possibly drives e-learning outcomes. Omoda-Onyait and Lubega (2011) introduce a model for e-learning institutional readiness assessment. Technology is one of the dimensions specified in the model. Alshaher (2013) proposes a model for e-learning system readiness assessment (ELSRA) consisting of strategy, structure, systems, style/ culture, staff, skills, and shared values. Systems comprise technology, content, platform support, and documentation. Technology and online instruction facilitate learning by enabling real-life contexts to engage students in solving complex problems and enriching learning experiences more than what can be done in F2F environments (Smart & Cappel, 2006). Technology readiness significantly influences technology adoption (Damerji & Salimi, 2021).

The successful transition to online learning is affected by technology usefulness (Aguilera-Hermida, 2020). The sudden shift from traditional to online classrooms during the COVID-19 resulted in different experiences for students, particularly those in underdeveloped areas, who do not have high-speed or reliable Internet services (Adnan & Anwar, 2020). Similar to the findings in the literature before the COVID-19, technical problems, e.g., Internet access, poor Internet speed, and difficulties in downloading and installing the online class applications, are reported as challenges faced in online lectures by more than 50% of students during the COVID-19 pandemic in the study of Akuratiya and Meddage (2020). The constraint of online learning is the availability of Internet services. Some students use cellular, and some of them use WiFi services at home (Laili & Nashir, 2021). In the study of Bączek *et al.* (2021), most students who have never experienced any form of e-learning before the pandemic mention technical issues as the second major disadvantage of e-learning. E-learning requires a reliable Internet connection and the necessary hardware and software. Both learners and educators have to be familiar with the equipment and should receive technical support and guidance from the IT department before and during online learning. Poor interaction between learners and lecturers can impede self-learning in online settings. Online classes have limitations, including problems with Internet access, poor Internet connection quality, and insufficient digital skills of respondents Chisadza *et al.* (2021) suggest that the improvement of digital infrastructure and reducing the Internet access cost are necessary for mitigating the impact of the COVID-19 on educational outcomes. Their findings reveal that students' performance in online settings positively correlates with better Internet access. The major challenges faced by higher education students in Pakistan are lack of access to Internet facilities and ineffective technology. Lack of resources in academic institutions, such as insufficient access, Internet availability, and the latest technology, influence organizational responsiveness and students' capacity to engage in digital learning (Adnan & Anwar, 2020). Accessibility means access to the Internet, a reliable device, and technical support. The accessibility is highly related to students' online learning during the COVID-19. Moving from educational institutions to their homes changes technological tools and support in their learning. The effective use of technology allows students and lecturers to engage and collaborate. Online or distance education implies that interactions between students and teachers are mediated by technology. Hence, the design of learning environments can have a considerable impact on learning outcomes (Aguilera-Hermida, 2020). Although students perceive online lectures are good enough, they are less satisfied with the implementation because of the support facilities like Internet quota. The implementation of online learning is not optimal or ineffective, particularly in rural areas, which the use of technology is limited. Students in rural areas often get unstable connections. They face problems if online learning cost more expensive than F2F learning. Learning through video conferences consumes a lot of the Internet data quota, compared to online discussions through Whatsapp. Bad internet access and poor signals for students in rural areas also cause miscommunication between students and lecturers. In conclusion, crucial factors in online learning are the availability of supporting tools and the stability of Internet access. Besides, online learning must be easy to access, attractive, and motivated (Laili & Nashir, 2021).

### **Online Experience, Gender, and Student Learning Styles and Online Preferences**

#### **Past experience**

Students' demographic characteristics, e.g., the previous experience, could impact their attitudes and perceptions of online education (Hilton *et al.*, 2020). The prior online experience is one of the variables relating to students' self-efficacy in online learning environments (Shen *et al.*, 2013). Kaushik and Agrawal (2021) state that the readiness for online learning of students having prior experience with digital learning tools may differ from students having no prior experience with digital technologies. Students who have no experience with online learning may think that online delivery mode is not desirable. Hilton *et al.* (2020) believe that the more online courses taken by students, the more positive perceptions of online learning students have. Experience during the COVID-19 is an emergent response to the global crisis and may not depict normal online learning instruction

(Aguilera-Hermida, 2020). Past studies point out that students pay much more attention to their overall educational experience than the individual aspects of a course (Dziuban & Moskal, 2011). If students' and professors' learning experiences are positive, they may increase online learning adoption. Conversely, they may avoid online learning if their experiences are negative (Aguilera-Hermida, 2020). It is evident that the use and experience of technology could increase its acceptance (Kaushik & Agrawal, 2021). If individuals have limited experience with basic computers, they may not adapt to new technologies easily and may suffer if such technologies are integrated into academics (Caison *et al.*, 2008). When individuals use technology constantly or have experiences with technology, they perceive ease of use and usefulness of technology even though they feel discomfort (Yusuf *et al.*, 2021). Individuals with online learning experience have more self-efficacy ratings than those without online learning experience (Zimmerman & Kulikowich, 2016). Shen *et al.* (2013) mention that instructors could find slow participation or failure to submit assignments in students who have less experience online. Past research shows that longer computer experiences of students significantly impact their achievement scores (Ho, 2009).

Many students in the study of Lopes (2007) think that e-learning features positively contribute to the teaching or learning experience. Liu (2010) believes that students are more satisfied with e-learning than F2F instructions in terms of teachers' characteristics, learning materials, and learning environments. On the contrary, in the study of Bali and Liu (2018), students rate F2F learning greater than online learning in all dimensions, showing their satisfaction and good experience in F2F learning. In the study of Nasution *et al.* (2021), almost all students choose offline learning rather than online. Qualitative data from the study of Aguilera-Hermida (2020) indicate that many students have an unpleasant experience in the online learning transition. They also express negative attitudes toward online learning. The study of Besser *et al.* (2020) compares two learning experiences. Participants reported significantly more stress, isolation, and negative mood in synchronous online learning than their experience in previous F2F learning. They also show significantly lower levels of positive mood, relatedness, concentration, motivation, and performance in online learning compared to traditional learning. Students enrolled in an online course in the study of Kuong (2015) enjoy learning experiences. All of them agree that online education is convenient, flexible, and enables more reflection time on learning materials. Even though their learning experiences are satisfied, not all of them will take another online course. Some of them choose F2F courses due to personal interactions and immediate feedback from instructors and fellow students. The majority of students who join an online Intensive English class in the study of Laili and Nashir (2021) agree or strongly agree that online learning simplifies the student-lecturer interaction, making them easier to convey opinions than F2F, making them more discipline in collecting the task. However, miscommunication with friends and lecturers occurs during their online learning, showing both positive and negative experiences in online learning. Young learners are increasingly entering schools with technology-specific experiences, which could affect learning outcomes (Warden *et al.*, 2020). Past research indicates that undergraduate students have more online experience, take more online courses, and tend to take online courses in the future more than graduate students (Shen *et al.*, 2013). Undergraduate students in the study of Keller and Karau (2013) tend to prefer online learning over F2F learning, but graduate students prefer traditional courses because of their experience in undergraduate degrees and less familiarity with online courses. People with little experience also expect digital technologies to echo conventional pedagogies (Warden *et al.*, 2020).

### **Gender**

Males and females are different in their technological expectations and take different roles in online learning environments. Hence, the gender factor is needed to be further investigated (Lu *et al.*, 2003). Student demographics in terms of gender could affect their attitudes and perceptions about online education (Hilton *et al.*, 2020). There is a significant interaction between topic interest and gender (Shakourzadeh & Izadpanah, 2020). Gender may also affect the impact of attendance on students' performance (Cortright *et al.*, 2011). The literature points out that females tend to be more persistent in online education than males (Lu *et al.*, 2003). Past research indicates gender influencing students' self-efficacy in online learning. Female students have higher self-efficacy compared to males (Shen *et al.*, 2013). The conventional wisdom or belief that grades are linked to class attendance appears to be corrected for female students only (Cortright *et al.*, 2011). Past research states that there is a strong body of evidence regarding women being inherently more successful in online learning environments than men. The majority of male students prefer F2F courses, whereas the majority of females prefer online courses. Female students also have stronger intrinsic motivations to take online courses than male students. Some studies also point out that females post more messages in online classroom discussions than males (Hilton *et al.*, 2020). Findings in the study of Caison *et al.* (2008) indicate that male medical students have greater overall technology readiness attitudes than female medical students. Thus, females with lower technological readiness than males may face more difficulty in adapting to the introduction of advanced technologies. There are some cases that girls report the use of technology as uninteresting but lectures as interesting, while some boys view lectures as uninteresting (Swarat *et al.*, 2012). Findings in the study of Alsaaty *et al.* (2016) show distinct differences between males' and females' perceptions. Many male students (48.4%) think online courses are easier to complete than F2F courses, but only a few females (32.9%) agree. However, many females (41.2%) believe online learning is superior to F2F compared to 19.4% of male respondents. Some studies found no differences in the Internet or online communication self-efficacy between genders (Shen *et al.*, 2013). Gender does not significantly affect students' choice of learning model in the study of Liu (2010). Gender does not impact students' evaluation of whether the learning objectives of a course can be better achieved in online or F2F sessions (Paechter & Maier, 2010). Hilton *et al.* (2020) specify that previous studies have shown mixed findings with regards to gender differences and online learning. Analysis by gender in their study also does not reveal any significant differences.

### **Student learning styles**

Researchers have found that the difference among learners who succeed and fail in online learning is based on personal characteristics (Murdock *et al.*, 2012). Personality variables significantly affect the predictions of synchronous online learning experience over the F2F learning experience, while adaptability significantly impacts personality variables (Besser *et al.*, 2020). Becoming an online learner requires a unique characteristic (Cleveland-Innes & Campbell, 2012). Literature indicates student characteristics such as proactive personality and learning goal orientation influence the outcomes of e-learning (Ho, 2009). Student efforts are rated significantly higher in online courses than in F2F courses. These ratings could be impacted by other factors, such as student characteristics. The efforts should be made to examine students' learning needs and to understand learners' characteristics. The analysis of students' traits and learning styles could help to determine their requirements and learning preferences (Tratnik *et al.*, 2019). There are several characteristics of students, such as learning preference, which could be a reason that students choose an online course over a F2F course (Young & Duncan, 2014). Different learners have different cognitive processes and learning style preferences. An individual's learning style influences how information is processed and his/ her learning efficiency and effectiveness. Three learning preferences are dependent learners, collaborative learners, and autonomous learners (Bencheva, 2010). Various teaching modes and technologies may benefit some students who are independent thinkers, have different learning styles, and are self-motivated to work outside classrooms (Smith *et al.*, 2015). Literature on learning styles suggests that field-independent students are more flexible, less gregarious, and do best in an impersonal learning environment of online education, but the absence of personal contacts and clarifying discussions in the environment lead to learning difficulties for field-dependent students who are more socially oriented and extrinsically motivated (Lu *et al.*, 2003). Learning style preferences affect class attendance (Cortright *et al.*, 2011). In online learning, time flexibility could be a limitation for students who have less self-discipline (Bączę *et al.*, 2021). Keller and Karau (2013) believe that individuals with high conscientiousness to be responsible for their learning develop more positive perceptions of online learning. Students who feel transitioning to online is difficult and prefer self-study i.e., reading through class slides and notes more than assisted study i.e., joining live lectures or watching recorded lectures gain lower academic performance (Chisadza *et al.*, 2021). Student performances in terms of average grades between pre-lockdown and post-lockdown are three points lower for those who prefer self-study and are two points lower for those who think the transition to online learning is difficult (Chisadza *et al.*, 2021). Aragon, Johnson, and Shaik (2002) indicate that online students are reflective by watching and doing and learning by thinking more than F2F students. F2F students also greater use learning by doing in comparison to their online counterparts. On the contrary, a past study examines the effects of learning styles on student achievement in technical writing classes of undergraduate students. It found no effect of learning styles on student achievement. Another study exploring how different learning styles function in web-based courses. The results show that learning styles do not impact web-based learning achievement (Lu *et al.*, 2003). There are also no statistically significant differences in the WebCT MIS class achievement scores among online and graduate students when classified by their learning styles in the study of Lu *et al.* (2003). Kwak *et al.* (2019) suggest that there is no one-size-fits-all delivery method to maximize learning outcomes, but universities should enable multiple delivery methods to facilitate various learning needs of students.

## Hypotheses

According to the background literature review, the following hypotheses are proposed:

- H1: There will be a significant increase in the ratings of cognitive process dimension (a) remember, b) understand, c) apply, d) analyze, e) evaluate, and f) create) according to the revised Bloom's taxonomy (before vs. after attending an offline/ face-to-face class)*
- H2: There will be a significant increase in the ratings of cognitive process dimension (a) remember, b) understand, c) apply, d) analyze, e) evaluate, and f) create) according to the revised Bloom's taxonomy (before vs. after attending an online class)*
- H3: There will be a significant increase in the ratings of topic interests (before vs. after attending an offline/ face-to-face class)*
- H4: There will be a significant increase in the ratings of topic interests (before vs. after attending an online class)*
- H5: There will be a significant increase in the ratings of class attendance intention (before vs. after attending an offline/ face-to-face class)*
- H6: There will be a significant increase in the ratings of class attendance intention (before vs. after attending an online class)*
- H7: There is a significant difference in the ratings of cognitive process dimension (a) remember, b) understand, c) apply, d) analyze, e) evaluate, and f) create) according to the revised Bloom's taxonomy between students experiencing offline and online learning after attending the class.*
- H8: There is a significant difference in the ratings of topic interests between students experiencing offline and online learning after attending the class.*
- H9: There is a significant difference in the ratings of class attendance intention between students experiencing offline and online learning after attending the class.*
- H10: There is a significant difference in students' performance in terms of assignment scores between students experiencing offline and online learning after attending the class.*
- H11: There is a significant difference in the ratings of technology readiness (a) place, b) equipment, c) software, d) Internet) between students experiencing offline and online learning after attending the class.*
- H12: In offline learning, there is a significant difference in the ratings of cognitive process dimension (a) remember, b) understand, c) apply, d) analyze, e) evaluate, and f) create) according to the revised Bloom's taxonomy between dependent learners and others (collaborative and independent learners) after attending the class.*
- H13: In offline learning, there is a significant difference in the ratings of topic interests between dependent learners and others (collaborative and independent learners) after attending the class.*

- H14: In offline learning, there is a significant difference in the ratings of class attendance intention between dependent learners and others (collaborative and independent learners) after attending the class.
- H15: In offline learning, there is a significant difference in students' performance in terms of assignment scores between dependent learners and others (collaborative and independent learners) after attending the class.
- H16: In online learning, there is a significant difference in the ratings of cognitive process dimension (a) remember, b) understand, c) apply, d) analyze, e) evaluate, and f) create) according to the revised Bloom's taxonomy between dependent learners and others (collaborative and independent learners) after attending the class.
- H17: In online learning, there is a significant difference in the ratings of topic interests between dependent learners and others (collaborative and independent learners) after attending the class.
- H18: In online learning, there is a significant difference in the ratings of class attendance intention between dependent learners and others (collaborative and independent learners) after attending the class.
- H19: In online learning, there is a significant difference in students' performance in terms of assignment scores between dependent learners and others (collaborative and independent learners) after attending the class.
- H20: There is a difference between students attending online classes and students attending offline classes in their online preference.
- H21: There is a difference between male students and female students in their online preference.
- H22: There is a difference between dependent learners and others (collaborative and independent learners) in their online preference.
- H23: In offline learning, there is a difference between the level of perceived technology readiness (a) place, b) equipment, c) software, d) Internet) in online preference.
- H24: In online learning, there is a difference between the level of perceived technology readiness (a) place, b) equipment, c) software, d) Internet) in online preference.

## METHODS

The purpose of this research is to explore the perceptions regarding learning outcomes, technology readiness, experience, learning styles, and online preferences of undergraduate students enrolling in a business course (the Digital Technology for Business course) and the linkage among these variables in both online and F2F environments. This work also provides an in-depth understanding of students' opinions in online courses. This study was carried out in a business school at a university in Thailand. Because of the COVID-19 epidemic, as same as other areas in the world such as Sri Lanka (Akuratiya & Meddage, 2020) and Poland (Bączek *et al.*, 2021), the school unexpectedly changed from F2F to online learning in the middle of the 2nd semester in 2019 academic year. However, when the situation was better, the faculty changed the learning mode backed to F2F teaching in the 1st semester of the 2020 academic year. This change is an opportunity for this study to compare online and F2F delivery modes and provides a guideline for teaching and learning after the COVID-19.

The sample of this study was 44 of 46 registered students who participated in online or F2F sessions, which were a part of the Digital Technology for Business course. This course was one of the core courses for business students. Systematic sampling was applied to select students into online or offline classes. All students participating in the survey attended online or F2F sessions depending on their running numbers, which were sorted by their student id. Students with odd numbers were assigned to attend synchronous F2F sessions, whereas students having even numbers were assigned to self-study via asynchronous online sessions. According to the strict instruction, students could attend only one delivery method, but not both. Students in F2F sessions were studied on campus in the computer room. They also saw online clip production for online students. Professional video recorded production was conducted with assistance from the technical staff of the school. A high-end video camera and Zoom application were applied to record both Window screens and a lecturer's action. The recorded video classes for online students were posted on the Google classroom immediately, within one day after the offline sessions finished. Files and documents for practices were given to offline students in the computer room, whereas files and documents for online students were posted on Google classroom. Google classroom was applied for all students, but Excel files, documents, and recorded clips are for online students only. In conclusion, all students experienced online or offline delivery modes before answering the survey.

For the Digital Technology for Business course, MS Excel basics were chosen for the comparison because they were simple skill-based topics. The topics about using tools were may well-suited to explore in an online format since they require learners to hands-on practice. For using MS Excel, a lecturer could show how to use the tool and give students time to follow by themselves no matter what delivery mode they were in. Besides, other topics in the course tended to require more interactions from students. There were three sessions for using MS Excel, which required three hours each. Three sessions were taught in three consecutive weeks. The first two sessions were about the use of MS Excel for fundamental analysis. Their topics included setting up a workbook, manipulating workbooks and worksheets, working with data and tables, performing calculations on formulas and cell references, using basic functions such as count, sum, max, min, average, if, creating charts and graphics, formatting worksheet, cells, and defining styles, and printing worksheets and charts. After finishing all content, both online and offline, students were ordered to pair and apply Excel basics to their real-life situations. A student could only pair with another student who learned Excel basics in the same delivery method. Each pair of students was free to choose input data, design which functions or formulas to be used, and select the proper graphs or charts to present their data. The third session was for Q&A and the assignment presentation.

After experiencing MS Excel basics teaching in any mode, students were immediately asked to fill an online questionnaire to reflect their perceptions and opinions in their learning. A retrospective pre-test/post-test design was utilized to collect data regarding learning outcomes, i.e., the cognitive process of RBT, topic interest, and class attendance intention. In the retrospective design, participants completed a retrospective pre-rating of their perceptions after the intervention and at the same time as post-rating. Several studies supported the validity of retrospective ratings on intervention-related criteria (Archibald *et al.*, 2014). The questions for learning outcomes were adapted from past research, theory, and literature studies (Forehand, 2005; Tan & Hew, 2016; Thongmak, 2019). Technology readiness was extracted from previous studies (Akaslan & Law, 2011; Aydin & Tasci, 2005; Darab & Montazer, 2011; Mosa *et al.*, 2016). Student learning styles (dependent, collaborative, and independent) were developed from the study of Charkins *et al.* (1985). The frequency of reviewing materials in general, the top six of twelve aspects in learning that participants were giving importance developed from pros and cons of online/ offline learning (Bencheva, 2010), learning preference, opinions about suitable courses for online learning, and additional comments and suggestions for online learning successful, were also collected. The assignment scores represented students' performance in this study while attending online or F2F classes were used as an experience variable.

Because the sample size was small and the distribution of the outcome was unknown and could not be assumed to be approximately normally distributed (Sullivan, n.d.), this study applied nonparametric tests. Descriptive statistics were applied to explore demographic data. The nonparametric test equivalent to the dependent t-test was employed to evaluate hypotheses: H1 to H6. the nonparametric alternative to the independent t-test was also applied to test hypotheses: H7 to H19. The chi-square test for independence was used to assess hypotheses: H20 to H24. Quantitative content analysis was applied to extract opinions about suitable courses for online learning and suggestions for online learning success using a guideline from the study of Erlingsson and Brysiewicz (2017).

## RESULTS AND DISCUSSION

Of 44 participants, there were 37 female and 7 male students, conforming to the proportion of females over males in Thailand. Eleven of them were sophomore students, while the rest were freshmen. The age of students was ranged from 18 to 21, with an average age of 19. Due to the problems of pairing to do the assignment, there were 24 students who studied offline and 20 students who attended online classes. For the average frequency of reviewing materials in general, 15 participants reviewed lessons averagely 4 times per week; 13 participants reviewed materials approximately 2-3 times per month; 11 students reviewed content 4 times per month; 3 students studied materials less than 1 time per month. The average assignment score of all students was 4.7 from 5. There were 32 students who preferred offline learning, whereas 12 students chose online methods over offline. Most of the students choosing offline courses were consistent with the more students satisfied with traditional courses than online courses in the study of Young and Duncan (2014), the study of Bali and Liu (2018), and the study of Tratnik *et al.* (2019). Students also preferred F2F over online learning in the study of Aguilera-Hermida (2020), the study of Schlenz *et al.* (2020), the study of Valentino *et al.* (2021), and the study of Nasution *et al.* (2021). For the aspects in learning that all participants gave importance, the top six things that all students placed importance on were 'learning that can be repeated as many times as they want', 'a communication channel to contact teachers easily and immediately', 'ease of searching for information while studying as soon as they have questions', 'two-way communication with teachers to ask and answer questions', and 'flexible learning to learn from anywhere, at any time'.

Considering only students who chose offline learning, they paid attention to the same aspects. However, they gave precedence to the aspect 'flexible learning to learn from anywhere, at any time' as important as another two aspects, which were 'studying in a framed environment to increase concentration, such as a scheduled classroom' and 'learning that interacts and relationships are developed face-to-face.' For students who preferred online learning, most of them also chose the same factors as all students. Nevertheless, they expressed concern to the aspect 'flexible learning to learn from anywhere, at any time' as important as the aspect 'having a system or program to help manage classes and arrange content, to share resources in learning conveniently'. For student learning styles, dependent learners are defined as learners who generally prefer teacher-directed and courses with explicit reading assignments, explicit class assignments, a predetermined number of tests. Collaborative learners are learners who prefer group projects selective assignments, such as case studies. Independent learners are those who like to influence the content and structure of the course. They also like to have some roles in the determination of materials, the number of tests given, and so forth (Charkins *et al.*, 1985). Of all students, there were 31 students classified themselves as dependent learners, 9 students believed that they were collaborative learners, and 4 students chose their learning styles as independent learners. Therefore, this study classified student learning styles as dependent and non-dependent learners in further analyses.

### Overall Learning Outcomes

For pre- and post-learning outcomes in F2F sessions, Wilcoxon Signed-ranks tests indicated a significant increase in students' remembering Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 3.0$ ),  $Z = -4.295$ ,  $p = .000$ , a significant increase in students' understanding Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.5$ ),  $Z = -4.340$ ,  $p = .000$ , a significant increase in students' applying Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -4.336$ ,  $p = .000$ , a significant increase in students' analyzing Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -4.331$ ,  $p = .000$ , a significant increase in students' evaluating Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -4.320$ ,  $p = .000$ , and a significant increase in students' creating by Excel basics after attending an offline class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 3.0$ ),  $Z = -4.134$ ,  $p = .000$ .

= .000. A Wilcoxon Signed-ranks tests also revealed that students' topic interests were greater after students attending an offline class ( $Mdn = 5.0$ ) than before they attended the class ( $Mdn = 3.0$ ),  $Z = -3.848$ ,  $p = .000$  and their class attendance intention were greater after students attending an offline class ( $Mdn = 5.0$ ) than before they attended the class ( $Mdn = 4.0$ ),  $Z = -3.810$ ,  $p = .000$ .

For pre- and post-learning outcomes in online sessions, Wilcoxon Signed-ranks tests indicated a significant increase in students' remembering Excel basics after attending an online class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 3.0$ ),  $Z = -3.867$ ,  $p = .000$ , a significant increase in understanding Excel basics after attending an online class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 3.0$ ),  $Z = -4.011$ ,  $p = .000$ , a significant increase in applying Excel basics after attending an online class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -3.960$ ,  $p = .000$ , a significant increase in analyzing Excel basics after attending an online class ( $Mdn = 4.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -3.994$ ,  $p = .000$ , a significant increase in evaluating Excel basics after attending an online class ( $Mdn = 4.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -3.968$ ,  $p = .000$ , and a significant increase in creating by Excel basics after attending an online class ( $Mdn = 5.0$ ) compared to before attending the class ( $Mdn = 2.0$ ),  $Z = -3.952$ ,  $p = .000$ .

A Wilcoxon Signed-ranks tests also revealed that topic interests were greater after students attending an online class ( $Mdn = 5.0$ ) than before they attended the class ( $Mdn = 3.0$ ),  $Z = -3.861$ ,  $p = .000$ . However, attending an online class did not change class attendance intention significantly ( $Z = -1.650$ ,  $p = .099$ ). Therefore, there is enough evidence to support hypotheses:  $H1a - H1f$ ,  $H2a - H2f$ ,  $H3$ ,  $H4$ , and  $H5$ , but not  $H6$ .

The significant improvements in learning outcomes after online or offline learning accorded with the significant increase of students' knowledge and research self-efficacy between pretest and posttest in the study of Brown and Park (2016) and the positive effects of webcasts on students' learning experiences and performance in the study of Traphagan *et al.* (2010). The increase of topic interest after attending online sessions was supported by the study of Swarat *et al.* (2012) mentioned that the use of technology could effectively enhance students' interest and motivation.

### **Online Learning versus Offline Learning (Learning Outcomes and Technology Readiness)**

#### **Learning outcomes**

For pre-learning outcomes between online and offline sessions, from the data, it can be concluded that remembering ( $U = 219.0$ ,  $p = .609$ ), understanding ( $U = 238.0$ ,  $p = .961$ ), applying ( $U = 221.5$ ,  $p = .653$ ), analyzing ( $U = 225.0$ ,  $p = .713$ ), evaluating ( $U = 219.0$ ,  $p = .608$ ), creating ( $U = 211.0$ ,  $p = .483$ ) Excel basics after attending an online class were not significantly different between students experiencing offline and online learning before attending the class. In addition, topic interest ( $U = 231.5$ ,  $p = .837$ ) and class attendance intention ( $U = 194.0$ ,  $p = .262$ ) were not significantly different between students experiencing offline and online learning before attending the class.

For post-learning outcomes between online and offline sessions, a Mann-Whitney test indicated that evaluating Excel basics was significantly higher for offline learning ( $Mdn = 5.0$ ) than for online learning ( $Mdn = 4.0$ ),  $U = 147.5$ ,  $p = .022$ , class attendance intention was significantly higher for offline learning ( $Mdn = 5.0$ ) than for online learning ( $Mdn = 4.0$ ),  $U = 110.0$ ,  $p = .001$ . However, there were no significant differences in remembering ( $U = 195.5$ ,  $p = .251$ ), understanding ( $U = 180.5$ ,  $p = .138$ ), applying ( $U = 239.5$ ,  $p = .990$ ), analyzing ( $U = 170.5$ ,  $p = .080$ ), and creating ( $U = 196.5$ ,  $p = .275$ ) Excel basics, topic interests ( $U = 198.0$ ,  $p = .286$ ), and assignment scores ( $U = 200.0$ ,  $p = .268$ ) between students experiencing offline and online learning after attending the class. Hence, there is enough evidence to support hypotheses:  $H7e$  and  $H9$ .

The significant differences in the cognitive process of RBT (evaluating) and class attendance intention were supported by a significant difference between online and offline groups in terms of perceived learning efficiency in the study of Smith *et al.* (2015), higher learning outcomes for skill-based courses in F2F sessions than online sessions in the study of Callister and Love (2016), the larger positive changes in students' self-efficacy of students in F2F than in other environments in the study of Thai *et al.* (2020). The insignificant differences in other perceived learning outcomes could be explained by the study of Dziuban and Moskal (2011), stating that the course modality did not impact the students' evaluation of course experiences, the study of Anggrawan and Jihadil (2018) concluding that no differences learning impacts between online and F2F learning, the study of Cleveland-Innes and Campbell (2012) showing no difference effective learning outcomes among two modes, and the study of Brown and Park (2016) presenting no differences in self-reported knowledge and self-efficacy of online and F2F students. The insignificant difference in students' performance between students experiencing offline and online learning after attending the class yielded the contrary results from the study of Liu (2010), indicating the higher learning effectiveness in online learning than F2F learning, and the study of Bączek *et al.* (2021) and the study of Valentino *et al.* (2021) pointing out that online classes were less effective than traditional classes. However, the findings tallied with the study of Lu *et al.* (2003) and the study of McFarland and Hamilton (2005) showing the insignificant difference in students' course grades between online and offline groups, the study of Murdock *et al.* (2012) revealing insignificant differences between the mean of GRE scores of online versus offline students, the study of Schwartz (2012) pointing out that online accounting classes did not become less effective than a traditional classroom, the study of Biel and Brame (2016) reviewed small scale studies and found that six of eight studies showed no significant difference between F2F and online sections, the study of Smith *et al.* (2015) showing no significant differences in students' performance in online and offline instructions, and the study of Akuratiya and Meddage (2020) showing that students perceived online learning as effective as F2F learning. The insignificant increase of class attendance intention after participating in online learning harmonized with the study of Stark (2019) indicating lower levels of motivation in online students compared

to F2F students and the study of Laili and Nashir (2021) indicating that online learning was boring, but differed from the study of Schlenz *et al.* (2020) specifying that online platforms motivated students to learn.

### **Technology readiness**

For technology readiness between online and offline sessions, Perceived technology readiness in terms of place in the offline group ( $Mdn = 6.0$ ) was statistically significantly greater than the perception of students in the online group ( $Mdn = 5.0$ ),  $U = 88.0$ ,  $p = .000$ . Perceived technology readiness in terms of equipment in the offline group ( $Mdn = 6.0$ ) was statistically significantly higher than the perception of students in the online group ( $Mdn = 5.0$ ),  $U = 105.0$ ,  $p = .000$ . Perceived technology readiness in terms of software in the offline group ( $Mdn = 6.0$ ) was statistically significantly more than the perception of students in the online group ( $Mdn = 5.0$ ),  $U = 102.0$ ,  $p = .000$ . Nevertheless, there were no statistically significant differences in technology readiness in terms of the Internet between the two groups ( $U = 231.0$ ,  $p = .819$ ). Thus, there is enough evidence to support hypotheses: H11a – H11c, but not H11d.

The significant differences in technology readiness (place, equipment, and software) of online and offline students were supported by the study of Laili and Nashir (2021), indicating the importance of the availability of supporting tools. Technical problems with IT equipment were also one of the disadvantages raised by students in the study of Bączek *et al.* (2021).

### **Dependent Learners versus Others (Learning Outcomes)**

For offline students' post-learning outcomes between dependent and non-dependent learners, A Mann-Whitney test showed no statistically differences in remembering ( $U = 58.5$ ,  $p = .599$ ), understanding ( $U = 44.0$ ,  $p = .174$ ), applying ( $U = 45.0$ ,  $p = .194$ ), analyzing ( $U = 61.0$ ,  $p = .726$ ), evaluating ( $U = 45.5$ ,  $p = .194$ ), and creating ( $U = 41.5$ ,  $p = .123$ ) Excel basics, topic interests ( $U = 53.0$ ,  $p = .411$ ), class attendance intention ( $U = 61.0$ ,  $p = .726$ ), and assignment scores ( $U = 43.5$ ,  $p = .155$ ) between dependent learners and others (collaborative and independent learners) after attending the offline class. Therefore, there is not enough evidence to support hypotheses: H12 – H15.

For online students' post-learning outcomes between dependent and non-dependent learners, A Mann-Whitney test revealed no statistically differences in remembering ( $U = 27.5$ ,  $p = .682$ ), understanding ( $U = 13.5$ ,  $p = .080$ ), applying ( $U = 27.5$ ,  $p = .682$ ), analyzing ( $U = 12.0$ ,  $p = .064$ ), evaluating ( $U = 20.5$ ,  $p = .290$ ), and creating ( $U = 26.0$ ,  $p = .617$ ) Excel basics, topic interests ( $U = 12.5$ ,  $p = .064$ ), class attendance intention ( $U = 29.5$ ,  $p = .820$ ), and assignment scores ( $U = 32.0$ ,  $p = 1.000$ ) between dependent learners and other learner types after attending the online class. Hence, there is not enough evidence to support hypotheses: H16 – H19.

The insignificant relationships between student learning styles and learning outcomes showed the contrast results with the study of Besser *et al.* (2020), highlighting that personality traits were associated with reactions to online learning, but presented similar findings with the study of Lu *et al.* (2003), which showed no significant interaction between learning styles and instruction methods based upon course grades.

### **Online Experience, Gender, Student Learning Styles, Technology Readiness and Online Preference**

For online experience and learning preference, a chi-square test of independence was performed to examine the association between the online experience and online preference. The association between these variables was not significant,  $\chi^2(1) = 2.994$ ,  $p = .084$ . So, there is not enough evidence to support hypothesis H20.

For gender and online preference, a chi-square test of independence was conducted to test The association between gender and online preference. The association between these variables was not significant,  $\chi^2(1) = 1.019$ ,  $p = .313$ . Thus, hypothesis H21 is not supported.

For student learning styles and learning preference, a chi-square test of independence was employed to investigate the association between student learning styles (dependent learners and others) and online preference. The association between these variables was not significant,  $\chi^2(1) = 3.567$ ,  $p = .059$ . Thus, there is not enough evidence to support hypothesis H22.

For perceived technology readiness of offline students and learning preference, chi-square tests of independence were applied to investigate the associations between technical readiness of students in the offline class and online preference. The association between technical readiness (place) and online preference was insignificant,  $\chi^2(1) = .600$ ,  $p = .439$ . The association between technical readiness (equipment) and online preference was not significant,  $\chi^2(1) = .000$ ,  $p = 1.000$ . The association between technical readiness (software) and online preference was insignificant,  $\chi^2(2) = .240$ ,  $p = .887$ . The association between technical readiness (Internet) and online preference was insignificant,  $\chi^2(3) = 1.629$ ,  $p = .653$ . Hypotheses H23a – H23d are thus not supported.

For perceived technology readiness of online students and learning preference, chi-square tests of independence were utilized to explore the associations between the technical readiness of students in the online class and online preference. The relationship between technical readiness (place) and online preference was not significant,  $\chi^2(3) = .972$ ,  $p = .808$ . The relationship between technical readiness (equipment) and online preference was insignificant,  $\chi^2(4) = 9.444$ ,  $p = .051$ . The relationship between technical readiness (software) and online preference was insignificant,  $\chi^2(3) = 4.524$ ,  $p = .210$ . The relationship between

technical readiness (Internet) and online preference was not significant,  $\chi^2(3) = 2.011, p = .570$ . Therefore, hypotheses H24a – H24d are not supported.

The insignificant associations between variables and learning preferences could be explained by the benefits of both online and offline learning according to the study of Paechter and Maier (2010), the insignificant differences in learning preferences among the level of students in the study of Bali and Liu (2018). An insignificant effect of gender on online preferences tallied with the insignificant differences among gender in student perceptions of learning and course satisfaction of online courses in the study of Hilton *et al.* (2020). The insignificant association between past experience and learning preferences yielded contrasting results to the findings of Hilton *et al.* (2020), pointing out that the more online courses student had taken, the more positive perceptions of online learning they had, but presented similar results to past research mentioned in the study of (Bali & Liu, 2018) that there was no statistically difference in learning preferences between two learning modes. Besides, the study of (Aragon *et al.*, 2002) specified that neither F2F students nor online students varied significantly according to their experience. The relationship between student learning styles and learning preferences was insignificant as same as the study of Lu *et al.* (2003).

## Students' Opinions

### *Suitable courses for online learning*

Of 20 opinions from students in online sessions and 24 opinions from students in offline sessions, there were 70 condensed meaning units extracted from 44 comments. Figure 1 shows suggested subjects or courses that students believed to be suitable for online learning. Many comments mentioned lecture-based, theory-based, memorized-based classes, which were mostly no practices, no interactions, and no group assignments attached and easy to read, research, and self-study. These aspects were generally embedded in General education (Gen-ed) courses in the university, which were aimed at laying the public or general knowledge for all undergraduate students. For technology-related courses, the results were mixed. Some students thought that technology-related courses, the courses using software, or information systems (IS) courses were suitable, whereas some other students denied applying the online method to the courses that required more resources or equipment. Besides, few students commented that online learning was suited for non-technology courses. Some students also supported using online methods with the subjects requiring more time from students to review lessons or having a lot of content. Some opinions supported online learning for all courses. However, another opinion said that no courses were 100% suitable for online methods.

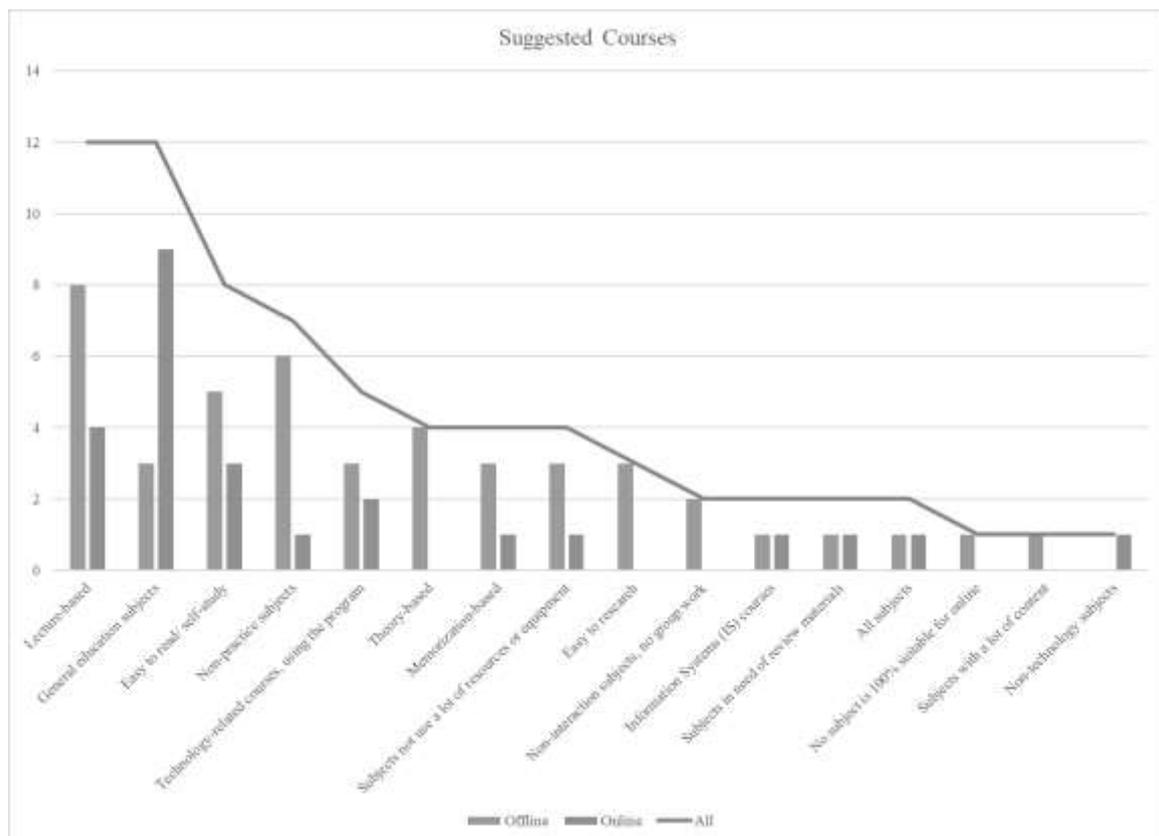


Figure 1: Suggested suitable course types from students.

### *Additional comments and suggestions for online learning successful*

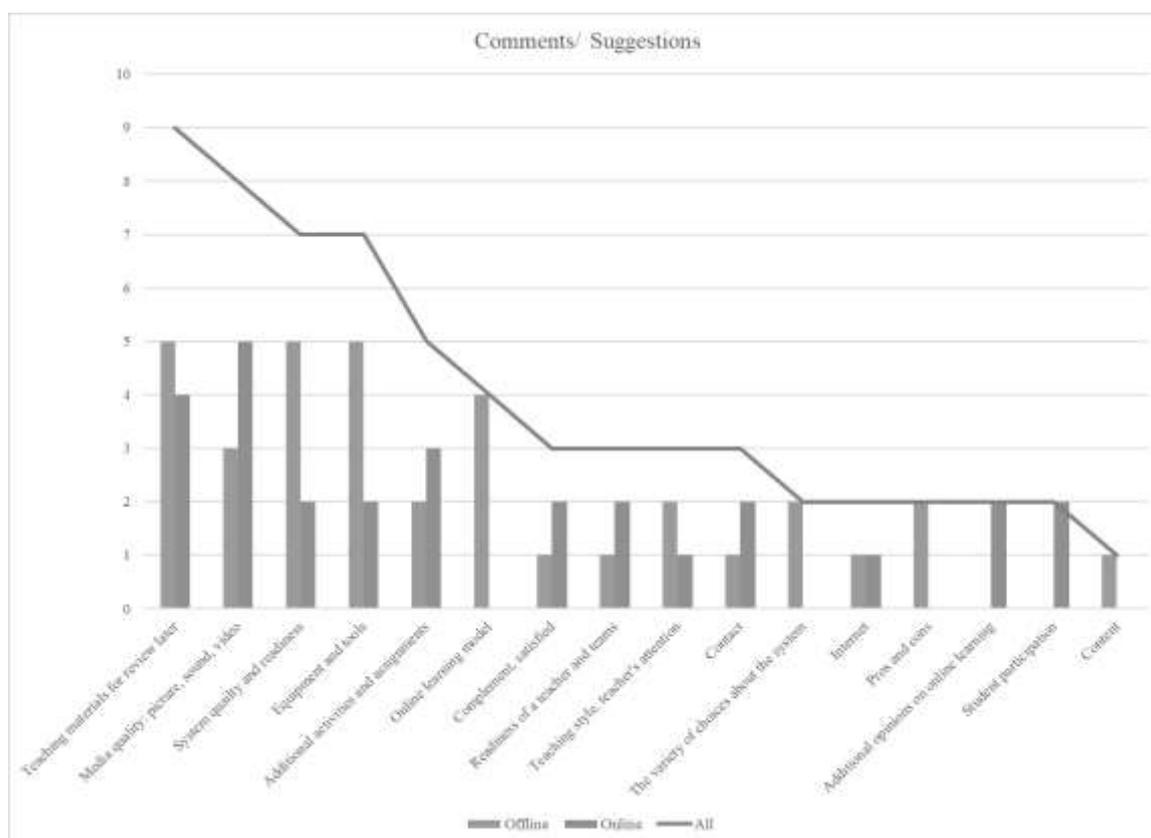


Figure 2: Students' comments and suggestions for the success of online learning.

Of 44 records of comments, 63 condense meaning units were extracted. Figure 2 shows the categories of suggestions for better online learning outcomes. First, both online and offline students mentioned teaching materials that should be provided online for students to review lessons. Students needed up-to-date recorded clips from both offline and online classes that were easy to access and repeatedly watch to review content or to view later in case they could not attend classes. Second, they needed good quality materials, no matter in sound, picture, or video formats. They worried about the quality of sound and pictures in video clips. Sounds as well as pictures in recorded clips should be clear and do not disappear. Third, students mentioned system quality and readiness. They needed fast, good, and stable systems or platforms such as Microsoft Stream and YouTube. Some students wanted more supports to facilitate their online learning. Some students suggested teachers post clips in the same place. Fourth, equipment and tools were mentioned. They needed equipment that was convenient and required more supports regarding equipment such as computers for using MS Excel. Fifth, they talked about additional activities and assignments. Students wanted more activities during online classes. Some students wanted more time, but few amount assignments. Some students did not want to spend too much time in front of screens due to concerns about health (eyes) problems. Sixth, students believed that online learning in synchronous mode was needed. They wanted interaction with instructors through an application such as Zoom rather than recorded videos. They wanted to ask questions immediately if they did not understand. They stated that they could not catch up on lessons like studying in classroom environments sometimes, for other comments and suggestions. Students gave compliments or felt satisfied with online learning. They believed that the readiness of lecturers, teams, and equipment was crucial. Some students needed teachers' attention to check whether they could catch up on lessons or not. Students wanted an online channel, which was easy to contact instructors and received quick responses. Some students needed a variety of learning choices. They wanted to choose delivery modes by themselves. Students wanted the faculty to facilitate their Internet connection. Some students believed that online learning had both advantages and disadvantages. Additional suggestions mentioned that online learning was suitable for not too complex or too difficult content as well as interesting content that convinced to focus easily. Some students wanted to participate or engage in the design of teaching and learning methods. Last, a student wanted recorded clips, which their content was completed.

Suggestions for better online learning conformed to the study of Bourzgui *et al.* (2020), describing that more than 50% of students had difficulty understanding materials online, thought interactive evaluation was not enough, believed that teaching could not be totally conducted online. Students' comments about easy access to online materials were also in line with the study of Akuratiya and Meddage (2020). The need for real-time interactions from instructors was in line with the need for real-time feedback from students in the study of Liu (2010), the significant higher communication in on-campus courses compared to online courses (Young & Duncan, 2014), the necessary of F2F learning for human interaction in the study of Julien and Dookwah (2020), the need of F2F interaction with instructors, fast responses by lecturers, facilitation by teachers, and classroom socialization in the study of Adnan and Anwar (2020), the study of Julien and Dookwah (2020), and the study of Nieuwoudt (2020). Efficient feedbacks and active interactions between teachers and students in e-learning were suggested to be enhanced in the study of Liu (2010). The study of Bali and Liu (2018) also revealed higher learning perception in terms of social presence and social

interaction in F2F over online learning. Providing various options and the availability of recorded classes to students for their learning was supported by the study of Nieuwoudt (2020) in terms of the flexibility of online learning for students to participate and interact online and to attend classes synchronously or asynchronously and the study of Akuratiya and Meddage (2020) supporting online learning as an option for future learning. Both pros and cons of online learning in students' viewpoints were supported by the study of Laili and Nashir (2021), confirming that students had positive and negative perceptions of online learning. The main advantages and disadvantages of online learning were also in line with the advantages and disadvantages mentioned in the study of Bączek *et al.* (2021). The needs for Internet support harmonized with the study of Chisadza *et al.* (2021) guiding that improving digital infrastructure and reducing the Internet access costs were necessary to mitigate the impact of the COVID-19 pandemic on educational outcomes and the study of Alsaaty *et al.* (2016) emphasizing that they encountered unreliable Internet connection during online learning. Students did not feel comfortable with online learning alone, conforming to the study of Schlenz *et al.* (2020). Additional activities or assignments suggested by students were consistent with the study of Nguyen *et al.* (2020), specifying the limitations of hands-on activities as a disadvantage of digital formats. The suggested courses and additional suggestions by students also accorded with the suggestions of Bourzgui *et al.* (2020) to improve course learning in terms of simplifying the course, doing some exercises, increasing hourly volume, and so on. The need for synchronous online learning from students differed from the study of Young and Duncan (2014), indicating that online students were more satisfied and benefited from asynchronous instructions.

### IMPLICATIONS

For theoretical implications, this study explores learning outcomes using different facets to investigate learning outcomes, i.e., the cognitive process dimensions of RBT, topic interest, class attendance intention together with student performance. These facets could be applied and expanded in future research to investigate learning outcomes in different delivery modes more than just online and offline learning, such as asynchronous online learning vs. synchronous online learning or flipped classroom vs. traditional F2F learning. Technology readiness is also explored in several dimensions. The comparisons between different delivery modes and student learning styles are conducted. Findings support the importance of learning environments but not learners' factors in terms of past experience, gender, and learning styles. This could guide researchers to explore deeply into learning methods and tools rather than learners themselves. Besides, learners' characteristics in classes are generally mixed, in which educators hard to control these factors.

For practical implications in the post-COVID world, instructors of the courses related to using basic tools can choose either online or offline methods to deliver the course content because both of them could enhance students' cognitive process dimensions in terms of remembering, understanding, applying, analyzing, evaluating, and creating and motivate their topic interest significantly. Both offline and online can increase all cognitive process dimensions for students. The research shows the difference in Evaluate category. Since the Evaluation facet needs students to check and critique. To maximize this performance, students need to perform with their classmates. Off-line class is where students can practice 'evaluating' much better than in an online class. There are advantages to both methodologies. For the synchronous F2F, students are allowed to interact with their instructors immediately once they encounter challenges to their cognitive process. In this fashion, students' cognitive processes will be enhanced in the classroom promptly. In addition, for learning through the recorded lesson, students are encouraged to repeat their views as frequently as they are willing to, particularly for difficult lessons or complicated Excel applications. Repetition of exposure to the recorded lesson will definitely enhance their cognitive process. Furthermore, asynchronous instruction provides flexibility for the students. Students are allowed to access digital materials in their demand manner. For this specific attribute, students may prepare their environments essential to their learning experience at the right time since they are aware of time and space appropriate to their learning process.

Although students' learning outcomes in terms of RBT cognitive process (evaluating content/ tool usage) and class attendance in offline classes are significantly higher than online students, other cognitive process dimensions, topic interest, and students' performance (assignment scores) do not significantly vary between groups. Therefore, educators could still effectively provide their courses online in addition to offline means. As a result, repetition of exposure to online lessons by in-class students may further improve their RBT cognitive process since they may engage this means after the off-line classes for their self-study for reviewing digital materials to enhance their understanding at any time. However, online sessions do not significantly improve students' class attendance intention as offline sessions do. Class attendance intentions of online students are also significantly lower than their offline counterparts. Most students also prefer offline classes rather than online. Since most of the students declare themselves as dependent learners, they tend to socially interact with others and seek assistance from their classmates. Besides, they also rate technology readiness, i.e., place, equipment, and software in on-campus classes significantly greater than in online classes. Therefore, if lecturers expect more class attendance in the fundamental tool courses, they should choose offline channels over online when the pandemic situation becomes better. Nevertheless, if universities or institutions aim at changing delivery methods to online, they should provide these technologies for students in need, for instance, letting students borrow computers and equipment and providing legitimate software in educational/ student versions. Skipping some online classes is possibly caused by indiscipline. Instructors may design a mechanism to manage students to induct disciplinary action for the online classes. Rewards like extra scores for attending all online classes or penalties like canceling the right to take a final exam if they skip a certain number of classes may be adopted.

For the demographic or background factors of students, e.g., their experience, gender, and learning styles. Since student demographics or backgrounds in classrooms are generally quite mixed and these factors do not associate with both students'

learning outcomes and preferences. Thus, educators could keep their focus on the design of content for each topic, in-class or online activities, and the improvement of students' technology readiness instead. Moreover, according to students' suggestions and comments, universities could apply the online learning format to lecture-based or general education classes that are quite easy for students to study by themselves. To make online courses better, universities should provide high-quality online materials and media for students to review, ensure the readiness of system, equipment, and tools, design more activities or assignments to support their engagement and interactions with instructors, and let them choose which delivery methods that they want if possible. For example, after online class, instructors may regularly set up the online round table where students may bring questions and fruitful discussion with their classmates and instructors. Doing so ensures the enhancement of both knowledge and cognitive process dimensions.

### CONCLUSION AND FUTURE RESEARCH

The purposes of this paper are to investigate learning outcomes of offline and online learning, to compare the differences of learning outcomes and technology readiness among channels and students' learning styles, and to explore the associations between demographic factors and students' online preferences. The cognitive process dimensions in Revised Bloom's taxonomy, topic interest, class attendance intention, and students' performance are applied as learning outcomes. Data, collected from undergraduate students enrolling in MIS 101 class in business school and participating in MS Excel basics online or offline sessions, are utilized to fulfill the research's purposes. Non-parametric statistics equal to dependent and independent t-tests and the test for relationships between categorical variables are applied. The findings reveal the improvement in learning outcomes in both online and offline sessions, except for the class attendance intention of online students. Online channels are inferior to offline channels in evaluating MS Excel and class attendance intention of students as well as the readiness of studying places, equipment, and software. No differences in students' learning styles and no significant relations between student backgrounds and their preferences are found in this study. This study guides institutions and educators after the COVID-19 pandemic in choosing suitable courses and proper delivery methods and adjusting learning facilities, supports, and activities for better online learning outcomes.

For limitations, the sample size in this study is quite small. This work is also limited to a Microsoft Excel basics topic in a single university. Future research thus should replicate this study in other basic tool courses with more undergraduate students from business schools in various universities to extend the research results to other academic subjects. Besides, this study is based on the class of one instructor, so future research may expand to other sections in the same courses to compare the influence of lecturers. In addition, there are few samples in some groups, such as male students, non-dependent learning styles, and online preferences. Future works should collect more data from each group to validate the research results. Students do not voluntarily attend or have a chance to select sessions that match their preferences to form their past experiences. Future research should provide them options regarding delivery methods and explore whether this flexibility yields satisfying outcomes in terms of students' online preferences. This study uses a self-reported instrument based on respondents' perceptions. Only students' assignment scores are an objective measure. Future studies should investigate students' learning outcomes using more objective measures such as exam results, total participation/ engagement duration, actual class attendance counts, and so on. Comparing various delivery methods in detail, for instance, flipped classroom, offline learning, asynchronous online learning through recorded videos, synchronous online learning via live sessions, and mixing between offline and online learning in the same course, should also be deeply investigated. Adopting cross-sectional and longitudinal approaches in the future could also strengthen and generalize the comparisons between online and offline teaching. Although this research aims to suggest educators and institutions after the COVID- 19 pandemic, researching in the middle of the pandemic could lead to different results from normal situations. Thus, future research should investigate students' perceptions and needs in the post-COVID time as well.

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## Prioritizing Critical Cloud Services for Disastrous Pandemics: A Media Richness Perspective

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### ABSTRACT

During the breakout of coronavirus disease (COVID-19), cloud computing applications provide great convenience and assistance for people, enterprises, and government units. So far, studies of the priority of cloud services under disastrous situations are relatively scant. This research thus examines supportive cloud services which influence the sustainability of people and organizations. An empirical study was performed using SMARTER method with data collected from industry experts. The results conclude a relative priority map of the cloud services facing pandemics. Research implications and suggestions are then elaborated.

*Keywords:* Cloud service, coronavirus disease (COVID-19), media richness, SMARTER, rank order centroid.

### INTRODUCTION

Since the beginning of 2020, the world has been confronting the epidemic of coronavirus disease (COVID-19). To prevent the contagion, many countries have restricted transportation, grounded airlines, closed public facilities, blocked traffics, sealed cities, and quarantined residents, making the provision of goods and services extremely difficult (Whitelaw *et al.*, 2020). During this abnormal period, electronic governments and businesses taking advantage of cloud computing technologies provide emergency relief to the people and organizations in need at home or worldwide under this disastrous situation (Tuli *et al.*, 2020).

However, research on the priority of various cloud services under disastrous situations is relatively little. In this study, we bring together theoretical and empirical analyses to explore the priority ranking related to cloud services under situational abnormality caused by disastrous pandemics.

The paper begins with a review of the theoretical background about media richness view and cloud applications facing pandemics. Supportive cloud applications for pandemic situations are collected from selected experts in Taiwan. Then it explains the SMATER method (Edwards & Barron, 1994). Following that, the SMATER method is applied to analyze the data collected from the experts. Finally, the findings are presented along with the managerial implications of the study and suggestions for further research.

### THEORETICAL BACKGROUND

#### Cloud Computing and Cloud Services

Cloud computing has gained vast attention because of its technological advancement and availability. Major benefits of adopting cloud computing in organizations are ease-of-use, convenience, on-demand access, flexibility, and least management from the users (Chou, 2015). The proven success of many cloud-based solutions, together with the benefit of a less expensive and more responsive business solution infrastructure, is prompting organizations to develop cloud services for cost-effective, accelerated IT provisioning in protected environments (Ristova *et al.*, 2013; Weng, 2021).

Cloud computing capability is an organizational capability of accessing and deploying an elastic resource of processing and storage power that is reconfigurable on-demand and with flexible costs on a pay-as-you-use basis. The ubiquity of cloud services is much like the availability of electric power, and thus cloud services are often analogized to utility services. The utilization of cloud computing capability can provide cheaper, faster, more flexible, and more effective computing power to both organizational and individual users. This pay-per-use model provides greater flexibility, promotes more rapid innovation, and is an alternative to capital expenditures (Berman *et al.*, 2012).

The elastic and scalable nature of a cloud service enables organizations to use IT resources more flexibly in response to fluctuation in the resource demand (Armbrust *et al.*, 2010). The service scalability also increases organizational agility in response to environmental changes (Garrison *et al.*, 2015). Moreover, a cloud service enables organizations to utilize on-demand IT functions with the latest technology, thereby sustaining their technological agility. Both flexibility and agility are considered strategic benefits because they enable organizations to rapidly initiate new services by allocating their resources to more value-centric tasks and by reducing the time needed to supply the required IT resources (Weng & Lin, 2014).

#### Media Richness of Cloud Services

Media richness theory was developed in the mid-1980s by organizational scholars Daft and Lengel, and became very popular along with the diffusion of electronic communication media (Daft & Lengel, 1986; Daft *et al.*, 1987; Ishii *et al.*, 2019). The

theory suggests the effective use of a communication channel or medium by matching the richness of a medium and the equivocality of the task (Daft & Lengel, 1986). Moreover, the theory paid attention to the significance of uncertainty and equivocality reduction in successful information processing in organizations. More specifically, uncertainty is the lack of information, which can be reduced by the quantity or amount of information (Galbraith, 1974). In contrast, equivocality refers to confusion or lack of understanding, which cannot be reduced by the amount of information but can be reduced by the quality or richness of information (Daft *et al.*, 1987).

In a mediated situation using communication technology such as cloud services, uncertainty reduction would not be the problem because a broadband cloud connectivity with big data technologies (Weng, 2020a) or the Internet of Things (Weng, 2020b) can carry a large amount of information to reduce uncertainty (Weng, 2020a). Equivocality reduction is problematic primarily due to the lack of nonverbal cues inherent in mediated communication and can be resolved through cloud streaming services such as video conferencing on smart mobile devices with augmented user interfaces (Yu *et al.*, 2018).

### Critical Cloud Services under Pandemics

In the COVID-19 pandemic situation, the significance of uncertainty and equivocality reduction becomes critical because face-to-face and in-person contacts are restricted (Chen *et al.*, 2020). Cloud services become effective media of communication among people in such a crisis (Gong *et al.*, 2020).

At the beginning of the pandemic, the Taiwanese government deployed cloud-based logistics quickly to allocate and distribute healthcare materials such as masks and medical alcohol to prevent the outbreak of COVID-19. Critical information infrastructures for medical status were set up in public facilities. Remote public services and distance education in schools were implemented efficiently with the help of cloud technologies (Dwivedi *et al.*, 2020).

Enterprises in Taiwan monitored their production and supply chain flexibility with cloud-based information systems (Bruque-Cámara *et al.*, 2016). Remote video conferencing and cloud-supported groupware helped the collaboration for employees distributed worldwide. Since most of the physical sales channels were restricted during the pandemic, many firms started deploying online marketing and mobile commerce for their products and services.

In the individual aspect, people use their smart mobile devices to assist in the monitoring of personal health conditions, gathering information of the spreading status, and tracing footprints of the infected. Social media and instant messaging were utilized to overcome restrictions on in-person contact. Many physical shopping and entertainment activities had to be replaced by mobile shopping and entertainment on-demand with cloud support (Dihal *et al.*, 2013).

All of these cloud-supported applications are interrelated, and their importance in reducing uncertainty and equivocality is different. To have a clear understanding of their priorities relative to each other, a multiple criteria decision-making (MCDM) process is required (Tang *et al.*, 1999; Wu *et al.*, 2011). The proposed method is elaborated on next.

## RESEARCH METHOD

### SMARTER Method

The Simple Multi-Attribute Rating Technique Exploiting Ranks (SMARTER) method is a modified upgrade version of the SMART (Simple Multi-Attribute Rating Technique) method (Barron & Barrett, 1996; Edwards & Barron, 1994; Edwards & Fasolo, 2001). The SMARTER method is a multiple criteria decision-making (MCDM) method. The main difference between SMARTER and SMART methods is the weighting technique. SMART is based on the elicitation procedure for weight comparison that facilitates the analysis, and SMARTER extends the ranking process. The weights of the criteria in the SMARTER method depend on the order of priority of importance and are assigned by using rank order centroid determination techniques (Chiu & Chiou, 2016; Jr-Yi & Ming-Chuan, 2014).

The SMARTER method is based on the assumption that each alternative consists of a number of criteria, and each criterion has a weight that shows how important it is compared to other criteria. Weighting in the SMARTER method uses values between 0 and 1, making it easy to compute and compare (Barron & Barrett, 1996; Edwards & Barron, 1994).

Decision-making with the SMARTER method is based on the importance or priority of the criteria. The rank order centroid technique assigns weight to each criterion according to the rank assessed by the priority (Ahn, 2011; Tangkesalu & Suseno, 2018). The SMARTER decision is formed with the pair-wise comparison that "criterion i is more important than criterion j, which is more important than criterion k" and so on, until the n-th criterion, expressed as  $a_1 \geq a_2 \geq a_3 \geq \dots \geq a_n$ , where  $a_i$  is the criterion with the i-th ranking. The rank order centroid technique is then applied to assign weights with the order of  $z_1 \geq z_2 \geq z_3 \geq \dots \geq z_n$ , where  $z_i$  is the weight for criterion  $a_i$ . Mathematically, if  $a_1 \geq a_2 \geq a_3 \geq \dots \geq a_n$ , then  $z_1 \geq z_2 \geq z_3 \geq \dots \geq z_n$ . The weights are computed as follows:

$$z_1 = (1 + 1/2 + 1/3 + \dots + 1/n) / n$$

$$z_2 = (0 + 1/2 + 1/3 + \dots + 1/n) / n$$

$$z_3 = (0 + 0 + 1/3 + \dots + 1/n) / n$$

.....

$$z_n = (0 + 0 + \dots + 0 + 1/n) / n$$

where  $n$  denotes the number of criteria.

In general, the rank order centroid weighting technique can be expressed in Equation (1):

$$z_j = \frac{1}{n} \sum_{i=j}^n \frac{1}{i} \quad (1)$$

where we have

$$\sum_{i=j}^n z_j = 1 \quad (2)$$

The basic principle of the SMARTER method can be illustrated by considering a decision problem with two criteria  $a_1$  and  $a_2$ , that is, the case of  $n = 2$ . If  $a_1$  ranks first, then by equation (1), its weight should be between 0.5 and 1 so that the midpoint (i.e., the centroid) of the interval of  $z_1 = (1 + 1/2)/2 = 0.75$  is taken as the approximate weight. Similarly, the weight of  $a_2$  will be the midpoint, or the centroid, between 0 and 0.5 and is obtained by  $z_2 = (0 + 1/2)/2 = 0.25$  by equation (1). In this case, equation (2) is satisfied with  $0.75 + 0.25 = 1$  (Barron & Barrett, 1996; Edwards & Barron, 1994).

### Decision Process

This study conducted literature review and industry expert interviews to collect the important cloud services during the COVID-19 pandemic. The decisional cloud services proposed by the experts and supported by the literature encompass the service domains that are most important to the government, business, and individual. These factors are categorized in Table 1.

Table 1: Cloud services facing covid-19 pandemic.

Sector	Critical cloud service	
Government cloud service	C01	Public health status and infection monitoring
	C02	Logistics and distribution of critical healthcare materials
	C03	Remote public services and distance education in schools
Business cloud service	C04	Production and supply chain flexibility monitoring
	C05	Remote collaboration of employees and business partners
	C06	Online marketing and mobile commerce
Personal cloud service	C07	Personal health monitoring and a footprint timeline tracing
	C08	Social media and instant messaging
	C09	Mobile shopping and entertainment

Source: This study.

In general, government cloud services are administrated and deployed by government units to provide information and public services for people. Business cloud services are owned and operated by enterprises to provide managerial services to their employees and business partners. Personal cloud services are provided by organizations or individuals to people for personal applications.

Moreover, these cloud services can be further categorized by their functionalities. The experts and literature suggest that critical cloud service functionalities coping with pandemic situations include management of surveillance (Ibrahim, 2020), collaboration (Zhao & Wu, 2020), and mobility (Moslem *et al.*, 2020). Table 2 exhibits the cloud services categorized by functionality.

Table 2: Cloud services facing covid-19 pandemic by functionality.

Sector \ Functionality	Surveillance management	Collaboration management	Mobility management
Government cloud service	C01 Public health status and infection monitoring	C02 Logistics and distribution of critical healthcare materials	C03 Remote public services and distance education in schools
Business cloud service	C04 Production and supply chain flexibility monitoring	C05 Remote collaboration of employees and business partners	C06 Online marketing and mobile commerce

Personal cloud service	C07 Personal health monitoring and a footprint timeline tracing	C08 Social media and instant messaging	C09 Mobile shopping and entertainment
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Source: This study.

The experts were then asked to rate the influence of each factor by ranking. The final results were described and discussed next.

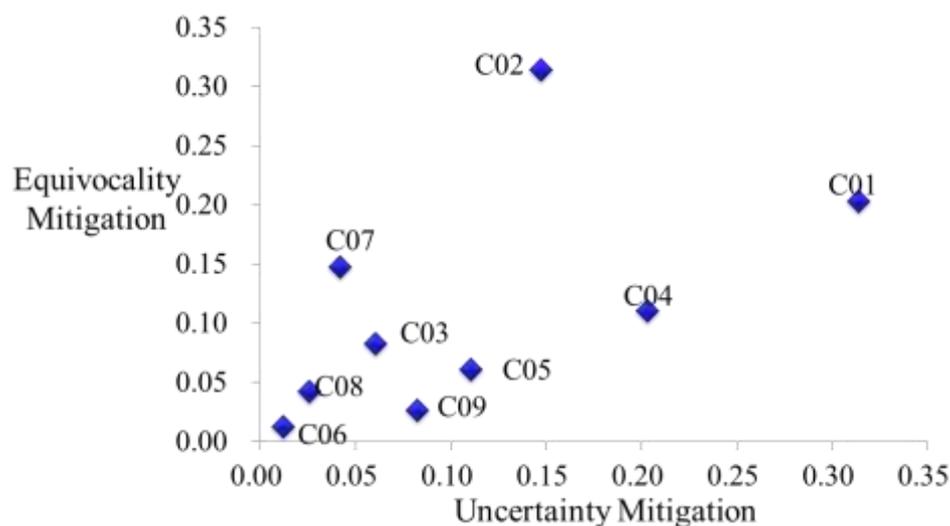
## RESULTS

The collected data of ranking of clouds in Table I for media richness comparison were obtained by voting of the experts. The comparison used uncertainty mitigation and equivocality mitigation as two dimensions for ranking. The corresponding weights were then assigned by using equation (1). The results are exhibited in Table 3 and Figure 1. The normalized total weight in Table 3 is obtained by normalizing the sum of the weights of uncertainty mitigation and equivocality mitigation.

Table 3: Ranking and weights of media richness of the cloud services facing pandemics.

Cloud service	Uncertainty mitigation		Equivocality mitigation		Normalized Total weight	Overall rank
	Rank	Weight	Rank	Weight		
C01	1	0.314	2	0.203	0.259	1
C02	3	0.148	1	0.314	0.231	2
C03	6	0.061	5	0.083	0.072	6
C04	2	0.203	4	0.111	0.157	3
C05	4	0.111	6	0.061	0.086	5
C06	9	0.012	9	0.012	0.012	9
C07	7	0.042	3	0.148	0.095	4
C08	8	0.026	7	0.042	0.034	8
C09	5	0.083	8	0.026	0.055	7

Source: This study.



Source: This study.

Figure 1: Media richness map of the cloud services facing pandemics.

Table 4 shows the total weights of media richness of the cloud service by category.

Table 4: Categorized total weights of media richness of the cloud services.

Functionality Sector	Surveillance	Collaboration	Mobility	Total
Government	0.259	0.231	0.072	0.562

Business	0.157	0.086	0.012	0.255
Personal	0.095	0.034	0.055	0.184
Total	0.511	0.351	0.139	1.000

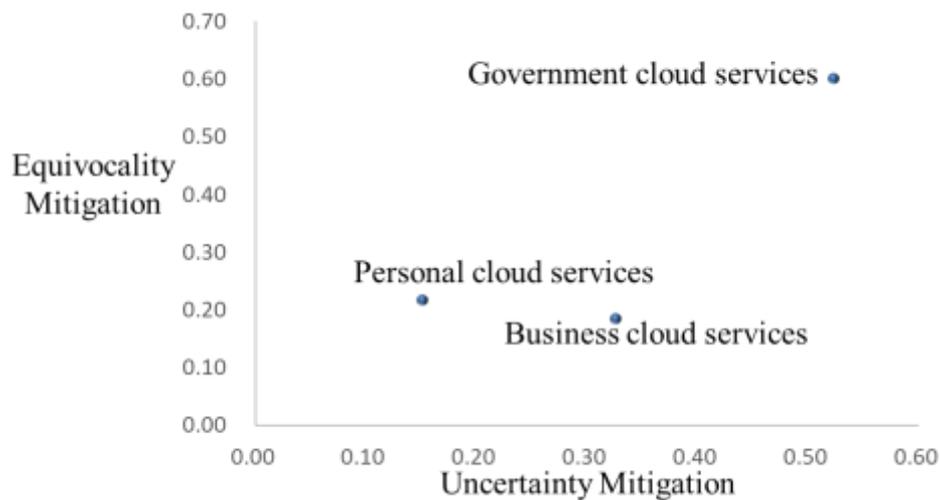
Source: This study.

Table 5 and Figure 2 exhibit the weights of cloud services grouped by sector for uncertainty mitigation and equivocality mitigation.

Table 5: Weights of media richness of the cloud services by sector.

	Government			Business			Personal		
	Cloud service	Uncertainty mitigation	Equivocalit y mitigation	Cloud service	Uncertainty mitigation	Equivocalit y mitigation	Cloud service	Uncertainty mitigation	Equivocalit y mitigation
Surveillance	C01	0.314	0.203	C04	0.203	0.111	C07	0.042	0.148
Collaboration	C02	0.148	0.314	C05	0.111	0.061	C08	0.026	0.042
Mobility	C03	0.061	0.083	C06	0.012	0.012	C09	0.083	0.026
Total weight		0.523	0.600		0.326	0.184		0.151	0.216

Source: This study.



Source: This study.

Figure 2: Media richness map of the cloud services by sector.

As shown in Figure 2, government cloud services are the most critical for uncertainty mitigation and equivocality mitigation when coping with pandemics. Business cloud services have a higher effect on uncertainty mitigation than equivocality mitigation. Personal cloud services have a higher impact on equivocality mitigation than uncertainty mitigation.

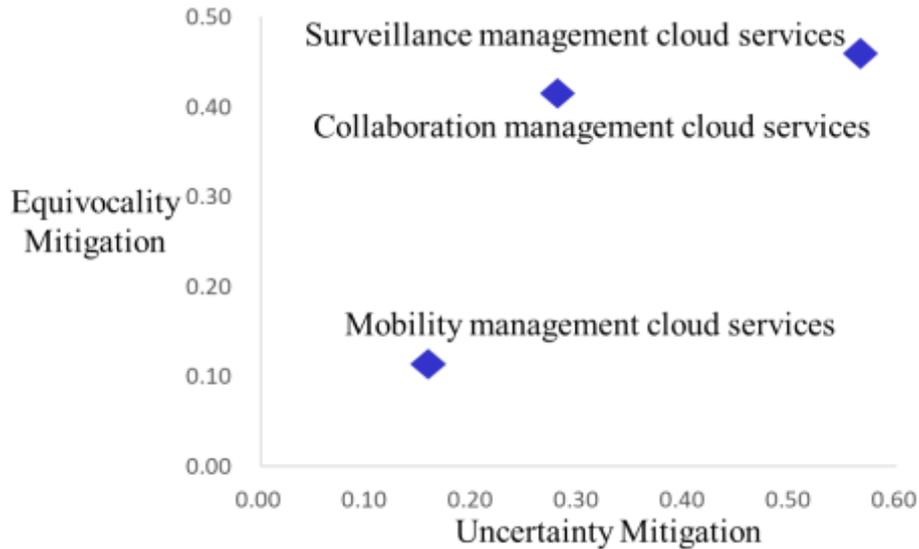
Table 6 and Figure 3 exhibit the weights of cloud services grouped by functionality for uncertainty mitigation and equivocality mitigation.

Table 6: Weights of media richness of the cloud services by functionality.

	Surveillance management			Collaboration management			Mobility management		
	Cloud service	Uncertainty mitigation	Equivocalit y mitigation	Cloud service	Uncertainty mitigation	Equivocalit y mitigation	Cloud service	Uncertainty mitigation	Equivocalit y mitigation

Government	C01	0.314	0.203	C02	0.148	0.314	C03	0.061	0.083
Business	C04	0.203	0.111	C05	0.111	0.061	C06	0.012	0.012
Personal	C07	0.042	0.148	C08	0.026	0.042	C09	0.083	0.026
Total weight		0.560	0.462		0.285	0.417		0.156	0.121

Source: This study.



Source: This study.

Figure 3: Media richness map of the cloud services by functionality.

As shown in Figure 3, surveillance management cloud services are the most critical for uncertainty mitigation and equivocality mitigation when coping with pandemics. Collaboration management cloud services have a higher effect on equivocality mitigation than uncertainty mitigation. Mobility management cloud services have a higher impact on uncertainty mitigation than equivocality mitigation.

Furthermore, the above results were obtained under the assumption of the equal importance of uncertainty mitigation and equivocality mitigation (i.e.,  $z_1 = z_2 = 0.5$ ). This assumption may require adjustment as the pandemic situation changes. For example, starting in May of 2021, the outbreaks of COVID-19 became deteriorated. The Taiwanese government raised the pandemic alert level from level 2 to level 3. At this time, the experts further compared the impacts of the two mitigation factors and decided that uncertainty mitigation will become more important than equivocality mitigation under the COVID-19 pandemic for the future scenario. Thus, by equation (1), the weight of uncertainty mitigation is adjusted to  $z_1 = 0.75$ , and the weight of equivocality mitigation becomes  $z_2 = 0.25$ . The adjusted results are exhibited in Table 7.

Table 7: Adjusted ranking and weights of media richness of the cloud services facing pandemics.

Cloud service	Uncertainty mitigation ( $z_1$ )		Equivocality mitigation ( $z_2$ )		Adjusted normalized total weight ( $z_1 = 0.75, z_2 = 0.25$ )	Overall rank
	Rank	Weight	Rank	Weight		
C01	1	0.314	2	0.203	0.287	1
C02	3	0.148	1	0.314	0.189	2
C03	6	0.061	5	0.083	0.066	7
C04	2	0.203	4	0.111	0.180	3
C05	4	0.111	6	0.061	0.098	4
C06	9	0.012	9	0.012	0.012	9

C07	7	0.042	3	0.148	0.068	6
C08	8	0.026	7	0.042	0.030	8
C09	5	0.083	8	0.026	0.069	5

Source: This study.

## DISCUSSION AND CONCLUSIONS

### Research Implications

During the unusual time of the COVID-19 pandemic, many innovative information services were developed and deployed to help mitigate the impacts of the epidemic. However, because of the limitation of resources and the urgency of situations, decisions on the priority of these information services are required. These decisions are usually complex and under time constraints. Through the media richness theory and the SMARTER method, this study provides a systematic and swift process to determine the priority of cloud services for confronting the COVID-19 epidemic.

From the results in Table 3, the cloud service for public health status and infection monitoring (C01) has the highest priority when facing the COVID-19 pandemic. This result suggests that government units should make the best effort to deliver this information service. Public health status is the key to realizing the impacts of the pandemic, and infection monitoring will reveal the effectiveness of the confrontation measures.

As exhibited in Figure 1, the cloud services that are most effective for uncertainty mitigation are public health status and infection monitoring (C01), production and supply chain flexibility monitoring (C04), and logistics and distribution of critical healthcare materials (C02). These cloud services help the reduction of information uncertainty and thus can effectively facilitate the functioning of government units and businesses. The cloud services that are most effective for equivocality mitigation are logistics and distribution of critical healthcare materials (C02), public health status and infection monitoring (C01), and personal health monitoring and footprint timeline tracing (C07). These cloud services help the reduction of information equivocality and thus can effectively help to achieve the peacefulness of personnel emotion.

Table 4 compares the relative importance of cloud services in different sectors and application functionality. For governmental and business sectors, cloud services of surveillance management applications are the most critical, followed by collaboration management applications and mobility management applications. For personal clouds, surveillance applications still have the highest priority (0.095) when facing a disastrous pandemic. However, mobility applications (0.055) have higher priority than collaboration applications (0.034).

Moreover, in different time periods of the COVID-19 epidemic, the impacts of information uncertainty and information equivocality may differ. An example of analyzing such a situation is exhibited in Table 7. In case that the requirement of information uncertainty mitigation is higher than information equivocality mitigation or vice versa, the rank order centroid weighting technique of the SMARTER method can be utilized to differentiate the relative importance. The results in Table 7 can be compared with the results in Table 3 and adjust the resources and schedules for the deployment of various cloud services.

### Suggestions

This study analyzes the relative importance of the cloud services which were deployed to mitigate the information uncertainty and equivocality using the media richness theory and the SMARTER method. Further research could use other approaches, such as the hierarchical analytic process (AHP), to analyze the impacts of the factors regarding the measures for confronting the COVID-19 pandemic. Moreover, the analyzing process in this study can be applied to specialized topics such as smart healthcare services facing the pandemic and impact factors for privacy and security in pandemic confrontation. Further investigations into these topics are recommended.

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## Research on Credit Evaluation System of E-business Enterprises from The Perspective of Organizational Resilience Theory

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### ABSTRACT

With the rapid development of the electronic business industry and the widespread of information technology, the credit issue of e-business enterprises becomes more and more important. Traditional e-business credit evaluation focuses on the accumulation of transaction credit. However, the widespread phenomenon of credit brushing leads to the deviation of credit evaluation of e-business enterprises. To improve the effectiveness of the credit evaluation system, this study introduced resilience-related indicators which represent the dynamic capability and sustainability of enterprises into the credit evaluation system. According to the organizational resilience theory, we capture e-business enterprises' credit from three dimensions: basic ability symbols, transaction process, and consumer feedback toward transaction outcomes. The potential influence of integrity grade, repeat purchase rate, return rate, and customer satisfaction were considered to mitigate the influence of deception on a credit evaluation. Combined with the analytic hierarchy process, this study constructed an adjusted credit evaluation model of e-business enterprises from the perspective of organizational resilience and tested the model with data from the Alibaba website. Fifteen considerable women's clothing e-business enterprises were selected for credit comparison. Results show that the top enterprise mainly had advantages over other enterprises in terms of the high repeat purchase rate, low return rate, and high consumer satisfaction. Theoretically, our study contributes to enriching the credit evaluation model of e-business enterprises and making an extension on the application of organizational resilience theory. In addition, these findings are helpful to optimize the effectiveness of credit evaluation of e-business enterprises, provide practical implications for e-business enterprises by identifying the key indicators to improve their credit in the uncertain trading environment, and reduce the transaction risk of e-business platforms.

*Keywords:* E-business, credit evaluation, analytic hierarchy process, cluster analysis, organizational resilience theory.

### INTRODUCTION

Enterprise credit has always been a critical concern in the e-business environment. Especially in the context of the COVID-19 pandemic, which has brought about delays in production and shutdown transactions, the credit of e-business enterprises has become increasingly important (Bhatti *et al.*, 2020; Jílková & Králová, 2021). Many e-business websites have established credit evaluation systems for e-business enterprises to reduce uncertain risks such as asymmetric information in online transactions. The most common method in the traditional evaluation system of e-business enterprises is time-accumulated credit evaluation, which evaluates the credit value by the cumulative average of the results of each transaction (Yoshino & Taghizadeh-Hesary, 2015). However, many businesses create fake transactions, leading to the deviation of credit evaluation. Due to the increasing uncertainty in the e-business trading environment, how to assess the credit of e-business enterprises more effectively is worth further attention.

Research on the existing enterprise credit evaluation system has put forward some improvement methods. For example, some scholars improved the accumulative credit evaluation system by considering the credit rating of the evaluated users (Piao *et al.*, 2007). The potential impacts of evaluated users' credit, transaction numbers, and amounts were discussed but lacked empirical tests. Some studies concerned about the information semantic recognition problem optimized the enterprise credit evaluation system through linguistic consensus model and fuzzy algorithm based on multi-attribute group decision-making theory (Chen & Yang, 2015; Li & Guo, 2021). Some studies focused on the enterprise default phenomenon, constructed specific indicators based on a multi-objective programming model to improve the credit evaluation system (e.g., Chi *et al.*, 2018). These findings are helpful to improve the credit evaluation in specific areas, such as the accuracy of language recognition of information. However, the evaluation system is relatively single and lacks dynamics.

E-business enterprise credit evaluation is different from general credit evaluation, which is specifically aimed at investigating, analyzing, and measuring the object's trustworthiness in electronic transactions. Due to the particularity of e-business, there are uncertain risks before the transaction, during, and after e-business transactions. The corresponding trustworthy behavior of the enterprise in each stage has a significant impact on the credit evaluation of e-business enterprises. However, traditional e-business rating systems less consider enterprises' long-term dynamic adaptability in pre-transaction and post-transaction stages.

Resilience, as an expression of the dynamic ability of an organization to adapt to the environment (Ortiz-De- Mandojana & Bansal, 2016), can well reflect the trustworthiness of an e-business enterprise in an uncertain environment. The perspective of organizational resilience theory provides a theoretical framework to better capture the evaluation index of e-business enterprise credit. Studies have analyzed the formation mechanism of organizational resilience at different stages from three dimensions of basic capacity, process, and outcome (Ortiz-de-Mandojana & Bansa, 2016). Facing risks in different stages, enterprises with high resilience have a good ability to adapt, recover and develop in an e-business environment. The findings in resilience literature suggest we consider the resilient related indicators in the evaluation system to better evaluate enterprise credit so as to improve the ability of enterprises to resist risks and uncertainties.

Accordingly, this study combines concepts related to organizational resilience and uncertain risks existing in each stage of e-business transactions and innovatively constructs an e-business enterprise credit evaluation index system. Based on the analytic hierarchy process (AHP), an e-business enterprise credit evaluation index system covering three first-level indicators and 13 second-level indicators is constructed. Empirical research was also conducted to test the validity of the model. Our study aims to provide an optimized approach for accurately evaluating the credit level of e-business enterprises and helping e-business enterprises to rectify defects and achieve sustainable development.

## LITERATURE REVIEW

### E-business Credit Evaluation System

A credit evaluation system, as a tool to disseminate credit information, helps to understand the credit status of the transaction parties, restrain the transaction behavior and reduce the transaction risk (Yang *et al.*, 2020). E-business credit evaluation is different from general credit evaluation. It is special for parties involved in e-business activities and assesses their trustworthiness. The special form of e-business business transactions demands that the evaluation system should have a procedural evaluation process, informative evaluation methodology, and timely evaluation results. Previous studies mainly explored the roles of enterprise's characteristics, external environment, and consumer factors in e-business credit evaluation system (Chen *et al.*, 2009; Gu *et al.*, 2017).

For the aspect of enterprise's characteristics. Previous findings mainly focused on the role of the financial index on credit evaluation (Abdou & Pointon, 2011; Chen *et al.*, 2009; Gama, 2012; Gu *et al.*, 2017). For example, some studies found the positive effect of enterprises' willingness and ability to repay a debt on their credit evaluation (Li & Guo, 2021). Besides, with the development of credit evaluation literature, more and more scholars are concerned about the non-financial index. For example, some scholars focused on the factors of previous credit, enterprise culture, organizational structure, and risk management ability (Abdou & Pointon, 2011; Hua, 2017). Some studies proposed that previous credit standing matters. The authors used the enterprise's loans and previous credit standing to evaluate the current credit (Chen *et al.*, 2009). In addition, managers play a significant role in the company. Empirical studies have been conducted to confirm the importance of managers for credit (Abdou & Pointon, 2011). Furthermore, some scholars are concerned about the factors about products and services, which have an impact on credit (Baesens *et al.*, 2003; Hazée *et al.*, 2020). These studies argue that these indicators can reflect the competitive ability and risk management ability.

For the aspect of the external environment, some studies concerned the factor about the economic environment, legal environment, credit environment, and industry environment (Delmas, 2002; Yoshino & Taghizadeh-Hesary, 2015). Generally speaking, a prominent macro environment is more favorable for building a credit evaluation system. In addition, some studies focused on the microenvironment, finding that the business category needs to be considered when evaluating an enterprise's credit evaluation system (Hua, 2017). Other studies also emphasized the importance of the justice of credit environment (Schuh, 2012). These studies help to understand the important potential impacts on an enterprise's credit from the stable and static perspective. However, it couldn't reflect the whole map for the e-business context.

For the aspect of consumer factors. Consumers, as an important part of e-commerce transactions, have a critical role in enterprises' credit evaluation (Munzel, 2016). Some scholars explored the impact on customer sharing, customer satisfaction, and consumer recognition (Hazée *et al.*, 2020). According to Hazée's work (2020), customer sharing represents the attitude of products and services, thus contributing to evaluating credit. In addition, some studies introduced consumer recognition into indicator systems, specifically measuring the sharing frequency and collection frequency to evaluate credit but lacked empirical tests (Sun *et al.*, 2015).

### Problem Identification

According to previous findings, the existing e-business credit evaluation system has some problems making it difficult to effectively reduce the evaluation bias. We identified the potential problems below.

#### *Deviation from the core features of e-business*

Compared with the traditional transaction process, e-business transactions have more uncertainty, which is determined by the special transaction form of e-business. Existing models are mainly concerned about the indicators of an enterprise's characteristics and external environment. These studies emphasized the role of financial factors such as asset-liability ratio (e.g., Gu *et al.*, 2017). However, they ignore the core feature and dynamic indicators in e-business transactions. Some scholars took consumer attitudes into consideration to solve this problem (Hazée *et al.*, 2020), but they do not have a segmentation of consumer

satisfaction at each stage and lack a dynamic process representation. So, the indicators which reflect the dynamic characteristic still need further improvement.

### ***Distortion of information***

Both empirical and practical evidence shows that deception is prevalent in the e-business credit evaluation process (Hua, 2017; Nick, 2016; Xiao & Benbasat, 2011). Some studies have explored ways to improve consumers' semantic understanding and information gain from the perspective of multi-attribute fuzzy evaluation, which helps to solve some of the information distortion problems (Kulak *et al.*, 2005), but it is difficult to address the credit speculation phenomenon. On the one hand, an enterprise may register multiple accounts to conduct fake transactions, which quickly enhances the credit evaluation. On the other hand, some consumers may also give a fake evaluation because of the enterprise's reward, resulting in distortion of credit degree. Some studies put effort into solving this problem. For example, some studies emphasized the consumer's reputation in the e-business environment (Munzel, 2016; Xiao & Benbasat, 2011) but lacked empirical tests.

### ***Lack of timeliness of evaluation***

Aside from the aspects mentioned above, the traditional e-business credit evaluation system uses the simple accumulation of the enterprise's credit through each transaction. But in fact, recent transaction indicators are of the greater reference value. Some studies called for that timeliness need to be considered in credit evaluation systems (Mansour, 2019). Therefore it is necessary to introduce more time-sensitive indicators in credit rating systems for e-business companies.

### **The Necessity and Feasibility of Bring Organizational Resilience Theory**

Resilience originated as a physical concept that refers to the ability to dynamically adapt to the environment (Brand & Jax, 2007). In recent years, resilience has been applied to different research fields, including psychology, ecology, engineering, economics, etc., spanning the research range from natural science to social science (Markman & Venzin, 2014; Ortiz-de-mandojana & Bansal, 2016). More and more scholars realized that resilience is the symbol of dynamic organizational capability which should be noticeable in the uncertain environment (Somers, 2009). The connotation of organizational resilience is based on the concept of development, which focuses not only on survival but also on dynamic sustainability through adaptation and learning (Miceli *et al.*, 2021). Some studies pointed out the importance of the three dimensions of a firm's basic capabilities, transaction processes, and outcomes in evaluating firm resilience. (Mark *et al.*, 2019; Ortiz-De-Mandojana & Bansal, 2016). The key connotation of organizational resilience theory provides an overarching framework for evaluating the dynamic process of e-business transactions. So, this paper makes a step on the existing e-business credit evaluation system from the perspective of organizational resilience theory.

Previous studies about resilience have been conducted, and some studies explored indicators of resilience. For example, some scholars introduced the degree of loss and recovery ability into a business resilience evaluation system (DesJardine *et al.*, 2019). Other studies concerned the factors about sales growth and financial volatility (Ortiz-de-mandojana & Bansal, 2016). Besides, Maria (2021) selected 29 non-financial indicators such as inventory levels to explore enterprises' resilience. These findings lay the foundation for this study to bring organizational resilience theory into an e-business context.

Accordingly, this study combines the characteristics of e-business transactions and the organizational resilience theory. We will comprehensively evaluate the credit of e-business enterprises from three main dimensions: representative indicators of overall enterprise capability before the transaction, time-sensitive key dynamic indicators during the transaction, and consumer feedback indicators after the transaction to improve the effectiveness of the evaluation. Our study helps to enrich the credit evaluation system research and expand the application of organizational resilience theory.

## **MODEL**

Based on the resilience theory and principles of index selection, considering the uncertainty factors in the e-business environment, we build the credit evaluation system in three dimensions: basic ability symbols, transaction process, and customer feedback about transaction outcome.

### **Principles of Index Selection**

The credit evaluation index directly affects the results of enterprise credit evaluation. Generally speaking, it contains credit evaluation elements and refines the evaluation content. Evaluation elements are limited to the general direction and are measured by a number of indicators. Based on the resilience theory, building enterprise credit evaluation system must follow the following basic principles:

**Relevance.** When selecting indicators, indicators that reflect little information should be deleted. For example, to reflect the Basic ability symbols, we select business year instead of the number of employees.

**Independence.** The building evaluation system should abide by the principle of independence. If there is a high correlation between the two indicators, they should be considered under the same first-level indicator, and the two first-level indicators should be independent of each other.

Pertinence. We need to set targeted evaluation indicators. Selecting indicators should reflect the content and purpose of evaluation. Based on the characteristics of e-business enterprises, this paper focuses on the enterprise credit evaluation from three aspects: pre-transaction, transaction, and post-transaction.

Availability. When selecting indicators, we should pay more attention to the availability of indicators. Considering the characteristics of e-business enterprises with light assets and heavy management, we will weaken financial indicators while strengthening non-financial indicators. Therefore, availability should be ensured in data collection.

Quantitative and qualitative combination. We adopt the principle of combining quantitative and qualitative indicators. Quantitative index and qualitative index are two types of credit evaluation index, respectively. Quantitative indicators refer to the data that can be expressed and calculated with specific figures, while qualitative indicators refer to the indicators that cannot be quantified. Combined with the two types of indicators, enterprise credit can be better measured.

**Build Credit Evaluation Index System**

When selecting indicators, we combine previous credit evaluation systems and the background of e-business enterprises, fully considering the influence of internal and external factors, following the principle of enterprise resilience, build e-business enterprise credit evaluation system as shown in Table 1.

Table 1: Credit evaluation index of e-business enterprises.

The indicator system	Level indicators	The secondary indicators
Credit evaluation index of e-business enterprises	Basic ability symbols	Business years (A11)
		Trust pass years (A12)
		Past credit grade (A13)
		Transaction medal (A14)
	Transaction process	Repeat purchase rate in recent 90 days (A21)
		Average delivery time in recent 90 days (A22)
		Industry average ratio of cumulative Trading volume in recent 90 days (A23)
		Refund rate in recent 90 days(A24)
		Industry average ratio of buyers in recent 90 days(A25)
	Customer feedback about transaction outcome	Product quality satisfaction (A31)
		Return and exchange experience satisfaction (A32)
		Logistics service satisfaction(A33)
		Response speed satisfaction(A34)

Source: This study.

In the evaluation system, considering the availability of data, we select three first-level indicators and 13 second-level indicators to reflect e-business enterprises' credit evaluation status. Among them, the first-level indicators include basic ability symbols, transaction process, and customer feedback about transaction outcome, which is elaborated in detail below.

First, basic ability symbols are the initial impression of the consumer. With the deepening of the transaction, although the consumer's perceived credit is constantly changing, the seller's initial credit can still reflect enterprises' strength, demonstrate corporate resilience, help consumers to evaluate the credit, and thus make better decisions. To measure the basic ability, we select four indicators: business years, trust pass years, past credit grade, and transaction medal. Business years refer to establishment time. The longer the business years, the stronger the continuous operation ability of the enterprise. Trust pass years refer to the length of membership of trust pass. Trust pass protects the rights and interests of consumers. Past credit grade is a set of standards launched by the Alibaba platform to measure corporate credit. It is divided into five grades, namely BB, BBB, A, AA, and AAA. To facilitate quantification, we assign 2, 4, 6, 8, and 10 points to each grade. Transaction medals are divided into five levels based on the transaction volume in the last 30 days. Similarly, this paper quantifies two points for each medal and so on.

Second, in an e-business transactions environment, the transaction of goods and the transfer of funds do not take place at the same time, so it leads to transaction risks such as refunds and delayed delivery. Transactions process indicators can provide consumers references to understand the transaction status to reduce purchase risk. To measure the transaction process, we mainly concentrate on six dimensions. Refund rate and delivery time in the transaction process reflect the unique characteristics of e-business enterprises. The repeat purchase rate and transaction volume in the last 90 days represent other consumer attitudes. The average industry ratio of accumulated transaction volume in the last 90 days is calculated by the number of transactions in the last 90 days divided by industry average trading volume. The calculation of the average industry ratio of the number of buyers in the last 90 days does the same.

Finally, consumer feedback about transaction outcomes is an important basis for repeat purchases, and it is critical for enterprises to achieve sustainable development. If consumer satisfaction is high, then the consumer perceived credit would increase, resulting in a higher credit score, which will help enhance enterprises' resilience. We measure by four indicators: product quality satisfaction, return and exchange experience satisfaction, logistics service satisfaction, and response speed satisfaction. They all represent positive correlation indicators. To facilitate the calculation, we assign 2, 4, 6, 8, and 10 points for each grade based on consumer evaluation.

**Determine Index Weight**

According to the above index system, we use the AHP method to determine the weight of each index. The analytic hierarchy process is to lists the factors related to the problem in layers. Usually, it can be divided into three layers, namely, the target layer, the criterion layer, and the scheme layer. Through calculation, we can obtain the weight value of the lowest layer relative to the highest layer and the optimal solution to the problem. Generally speaking, the analytic hierarchy process has three steps, that is, establish a hierarchy model, construct a judgment matrix, calculate weight, and consistency test. We will elaborate on this below.

**Establish hierarchical model**

In the above index system, we can regard e-business enterprises credit evaluation research as the target layer, and basic ability symbols, transaction process, and customer feedback about transaction outcome as the criterion layer. Other indices are the scheme layer.

**Construct the judgment matrix**

After completing the construction of the hierarchical model of the index system, we score the index according to the 1-9 scale method through pair-to-pair comparison. The specific scoring criteria can be seen in the following Table 2.

Table 2: Degree of judgment.

Indicator importance	Equally important	Slightly important	Obviously important	Strongly important	Extremely important
$u_{ij}$	1	3	5	7	9
$u_{ji}$	1	1/3	1/5	1/7	1/9

Source: This study.

Note:  $u_{ij}$  represents the importance of the former indicator relative to the latter indicator. In addition, 2, 4, 6, 8 represent the intermediate values of the above adjacent judgments.

**Calculate weight and consistency test**

In the calculation process, we can divide two steps, namely, calculate the weight of first-level indicators and consistency test and then calculate the weight of second-level indicators and consistency test. Here, we use the first-level indicators as an example to illustrate.

We compare basic ability symbols, transaction process, and customer feedback about transaction outcome in pairs and then use the 1-9 scale method. The resulting matrix is shown in Table 3 below:

Table 3: First-level index judgment matrix.

Enterprise's credit	Basic ability symbols	Transaction process	Consumer feedback about transaction outcome
Basic ability symbols	1	1/2	1/3
Transaction process	2	1	1/2
Consumer feedback about transaction	3	2	1

Source: This study.

We use the square root method to calculate the maximum eigenvalue and eigenvector and then normalize them to obtain the importance ranking of each indicator.

First, calculate the elements of each row of the judgment matrix  $M_i$ :

$$M_1=1/6, M_2=1, M_3=6$$

Second, calculate the square root  $W_i, n = 3$ :

$$W_1=0.55, W_2=1, W_3=1.82$$

Third, normalizing the vector, the feature vector is obtained:

$$W = (0.1632, 0.2967, 0.5400)^T$$

Fourth, calculate the maximum eigenvalue of the judgment matrix  $\lambda_{max}$ :

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{w_i} \tag{1}$$

$AW$  is the product vector of the judgment matrix and feature vector, the result is  $\lambda_{max} = 3.0092$ .

To verify whether the weight distribution obtained by the above calculation is reasonable, it is necessary to conduct a consistency test on the judgment matrix. The test formula is:

$$CR = \frac{CI}{RI} = \frac{\lambda_{max} - n}{(n-1)RI} \tag{2}$$

The value of RI is 0.58, as shown in Table 4, and the result is  $CR = 0.0046 < 0.1$ . Therefore, generally speaking, the judgment matrix is considered to pass the consistency test.

Table 4: RI.

<i>n</i>	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Source: This study.

Note: *n* represents the number of indicators in the judgment matrix, and RI represents the average random consistency indicator.

Therefore, we can get the weight of each indicator and the ranking of the importance of indicators, as shown in Table 5.

Table 5: Weighting and ranking of first-level indicators.

Enterprise's credit	Final weight	Comprehensive sequencing
Basic ability symbols	0.1632	3
Transaction process	0.2967	2
Consumer feedback about transaction outcome	0.5400	1

Source: This study.

So, we can get the final result, which is shown in Table 6.

**Construct Comprehensive Evaluation Index**

In the process of calculating comprehensive evaluation value, each indicator has different dimensions. To eliminate the differences caused by different dimensions, normalization is first required to standardize all data between [0,1]. The specific processing steps are as follows.

For positive indicators:

$$a_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{3}$$

For the negative index:

$$a_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \tag{4}$$

Based on the data, combining the comprehensive index formula:

$$Y = \sum_{i=1}^n \sum_{j=1}^m a_{ij} w_{ij} \tag{5}$$

The composite index is obtained by multiplying the weight of each indicator by its value.

Table 6: E-business enterprise credit evaluation index system.

The indicator system	Level indicators	First-level indicators Weight	The secondary indicators	Secondary indicator weights
Credit evaluation index of e-business enterprises	Basic ability symbols	0.1632	Business years (A11)	0.0195
			Trust pass years (A12)	0.0363
			Past credit grade (A13)	0.0327
			Transaction medal (A14)	0.0747
	Transaction process	0.2967	Repeat purchase rate in recent 90 days (A21)	0.0530
			Average delivery time in recent 90 days (A22)	0.0290
			Industry average ratio of cumulative Trading volume in recent 90 days (A23)	0.0803
			Refund rate in recent 90 days(A24)	0.0699
			Industry average ratio of buyers in recent 90 days(A25)	0.0645
	Customer feedback about transaction outcome	0.5400	Product quality satisfaction (A31)	0.2856
			Return and exchange experience satisfaction (A32)	0.1185
			Logistics service satisfaction(A33)	0.0838
			Response speed satisfaction(A34)	0.0522

Source: This study.

### EMPIRICAL TEST

#### Data and Preprocessing

As the largest online trading market and e-business exchange community in China, Alibaba gathers a large number of e-business enterprises. We select 15 e-business enterprises on the Alibaba platform to collect data. To eliminate the differences caused by different industries, we choose the industrial about women's clothing. We use the symbols (C1-C15) to indicate. According to the index system, the raw data are collected, which is as shown in Table 7.

Table 7: Sample enterprise index system.

	A11	A12	A13	A14	A21	A22	A23	A24	A25	A31	A32	A33	A34
C1	1	2	8	10	27%	1.27	9.71	13%	10.54	6	8.6	8	10
C2	1	9	8	10	16%	0.4	12.58	15%	17.93	6	8.8	6	8
C3	2	2	8	8	17%	0.9	7.21	9%	8.73	8	6	8	10
C4	17	9	10	10	35%	1.6	7.5	29%	5.72	6	6.4	6	6
C5	5	5	8	8	14%	1.1	14.68	19%	28.34	4	4.8	6	8
C6	7	8	8	4	6%	4.9	1.29	39%	4.29	4	6	4	6
C7	1	3	8	8	42%	1.04	2.12	10%	6.09	6	8	8	8
C8	5	2	8	6	13%	1.46	0.34	11%	0.89	6	6.6	8	8
C9	1	6	10	8	14%	6.2	8.82	57%	16.14	6	7.6	4	6
C10	2	1	2	4	23%	7.7	0.08	4%	0.11	0	6	0	10
C11	15	5	4	8	17%	1.9	2.53	21%	5.87	4	4	6	6

C12	8	1	6	4	6%	2.4	0.21	16%	0.71	10	10	6	10
C13	5	6	8	10	14%	4.1	13.68	50%	23.71	4	8	6	8
C14	3	4	10	8	24%	0.6	31.92	49%	15.13	8	7.6	6	10
C15	8	8	10	10	32%	1.8	9.06	40%	11.79	4	8	4	10

Source: This study.

### Application and Validity Test of The Model

According to the above calculation formula, we can obtain the comprehensive score and ranking of 15 enterprises, as shown in Table 8 below.

Table 8: Comprehensive score and ranking.

Company Name	Comprehensive credit	Rank
C7	0.7578	1
C3	0.7251	2
C1	0.7088	3
C12	0.6713	4
C8	0.6587	5
C15	0.5903	6
C6	0.5592	7
C2	0.4962	8
C9	0.4645	9
C4	0.4406	10
C13	0.3833	11
C14	0.3718	12
C11	0.3699	13
C5	0.3339	14
C10	0.2461	15

Source: This study.

### Evaluation Results

To make the analysis of evaluation result more scientific and reasonable, we use the method of cluster analysis to explain. The core idea of cluster analysis is to divide different clusters based on similarity or distance so that the similarity in the same cluster is as high as possible, and the difference between different clusters is as large as possible.

In this paper, we mainly use the k-means algorithm. By roughly dividing the credit evaluation score of these 15 enterprises, we divide them into four cluster centers and assign them into the most similar cluster. Therefore, we can obtain the following results through clustering.

Table 9: Final Clustering Results.

Number	Company name	Cluster	Distance
1	C7	1	.027
2	C3	1	.005
3	C1	1	.022
4	C12	4	.031
5	C8	4	.019
6	C15	4	.050
7	C6	3	.069
8	C2	3	.006
9	C9	3	.026
10	C4	3	.049

11	C13	2	.042
12	C14	2	.031
13	C11	2	.029
14	C5	2	.007
15	C10	2	.095

Source: This study.

According to the clustering results in the above table, we can obtain the following evaluation grades.

Table 10: Evaluation level.

Standard	>0.7	0.6-0.7	0.4-0.6	<0.4
Grade	excellent	good	medium	poor

Source: This study.

According to the clustering of 15 e-business enterprises, it can be seen that the comprehensive credit scores of C7, C3, and C1 are excellent. The reason for this result is that the refund rate in the last 90 days of these three enterprises is low, and the return rate in the last 90 days is high. The customer feedback is also generally prominent. Among them, the score of C7 is the highest. Through the data, we can know that the indicators related to customer satisfaction are all relatively high. Besides, the refund rate and repeat purchase rate perform better. Therefore, the comprehensive enterprise score is the best. The comprehensive credit scores of C12, C8, and C15 is good, compared with the enterprises with excellent scores, their customer feedback satisfaction is slightly lower, while the average industry ratio of buyers in the last 90 days, average industry ratio of accumulated trading volume in the last 90 days and refund rate in the last 90 days are far different from the enterprises with an excellent comprehensive credit score. It indicates that customer feedback satisfaction is roughly the same. The indicators related to the transaction process of the enterprise will directly affect the credit score of the enterprise. Among the remaining enterprises, we can see that the enterprises with medium and poor scores have significantly lower scores in two aspects: customer feedback about transaction outcome and transaction process. Among them, the comprehensive credit score of C10 was the worst. It is because that its product quality satisfaction and logistics service satisfaction scores are both 0, which is the root cause of its lowest score. At the same time, it also reflects the current e-business market is customer-oriented.

### Suggestion

Based on the above analysis of 15 e-business enterprises, we can see that resilience-related credit evaluation indicators are of great significance in enterprise credit evaluation. Therefore, the following suggestions are put forward for the above enterprises with low credit scores.

On the one hand, enterprises should take some measures to improve the repeat purchase rate and decrease the refund rate. It requires companies to focus on product quality. Specifically, enterprises need to form the consciousness of advanced prevention, process control, and supervision. Advance prevention means that enterprises should do their "homework" in advance, such as purchasing raw materials and choosing high-quality raw materials based on the principle of cost-effectiveness. Process control requires enterprises to integrate quality management into the whole process of production and operation and gradually reach the lean model of quality management. Supervision plays an important role, which directly determines whether the product is sold. If a large number of substandard products enter the market, then the life of the enterprise will be greatly shortened. So we need to improve the repeat purchase rate to enhance enterprises' resilience. In addition, enterprises should give some rewards to improve repeat purchase rates, such as giving preferential treatment to customers who repeatedly purchase.

On the other hand, enterprises should improve consumer satisfaction, including logistics service experience, return and exchange experience, and response speed experience. From the aspect of logistics service experience, enterprises can make efforts on the packaging of products. Then, enterprises can choose larger express delivery companies to cooperate with. Besides, enterprises should do a good job of logistics information follow-up work, ensuring that customers can timely and accurately obtain logistics information. From the aspect of return and exchange experience, enterprises should have a good attitude and inform the consumer of the detailed process, simultaneously asking why so that enterprises can improve next time. From the aspect of response speed experience, enterprises could be the system of working in shifts, trying to have someone available 24 hours a day.

## DISCUSSION AND CONCLUSION

### Theoretical and Practical Contribution

First, this paper contributes to the literature about e-business enterprise credit evaluation. The current evaluation system mainly uses the cumulative method to evaluate the credit of e-business enterprises. However, widespread phenomena such as credit speculation led to the deviation of evaluations. At the same time, problems such as lacking timeliness need to be solved. The dynamic capability perspective of organizational resilience provides a solution to this problem. Therefore, we build a theoretical model to evaluate enterprises' credit by considering organizational resilience theory and conduct empirical research to verify the model.

Second, this study makes an extension of organizational resilience theory. Organizational resilience theory emphasizes the ability of companies to recover, continue to survive, and sustain themselves after a shock. Studies have pointed out the important role of the three dimensions for organizational resilience assessment but lacks elaborate analysis of the three dimensions and index contents and empirical tests. This paper brings organizational resilience theory into the credit evaluation system to establish an adjusted credit evaluation model, expanding the application of the organizational resilience theory. At the same time, based on empirical research, our study finds that the indicators which represent consumer satisfaction and repeat purchase rate play an important role in evaluating the system. These findings make an extension of the content of the resilience-related indicators.

Aside from theoretical contribution, our study also has important practical implications for marketing strategy related to enterprises credit. First of all, the importance of corporate credit is to establish a corporate image and form a good reputation. Secondly, improving corporate credit helps companies to carry out economic activities and reduce the difficulty of obtaining financing, loans, and guarantees. Finally, enterprise credit evaluation helps enterprises to make scientific development plans, incorporate credit evaluation systems into enterprise development planning, and improve business management. From a practical point of view from the perspective of consumers, this research also helps to evaluate enterprises' credit and also helps people make more reasonable and rational decisions.

### Limitation and Future Directions

There are still some shortcomings in this research. First, this study focused more on the characteristics of e-business context and transaction process, so most indicators included in our model are non-financial indicators. However, it is also worth exploring whether the financial indicators would have any additional or interactive effects. At the same time, this study conducts the evaluation model based on the hierarchical analysis method. There is a strong subjectivity in scoring the indicators, and it is influenced by the inherent shortcomings of the hierarchical analysis method. This may directly affect the weight of each indicator. Therefore, the external effectiveness of indicators needs to be further verified. Finally, the empirical test is only conducted in the industry of women's clothing e-business enterprises. However, women's clothing e-business enterprises are a typical industry in an e-business environment. It is worth further testing the external validity of our findings and exploring the impacts of the indicators proposed in our credit evaluation model in other industries.

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## Research on the Construction Mechanism of Consumers' Trust Intentions and Behaviors in the Context of Live Streaming Shopping

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### ABSTRACT

As a new-type media form integrating text, image, video, and audio, live streaming itself is an excellent way of information-carrying and interaction. And the development of information technology makes the use of live streaming shopping easier and more convenient. At the same time, with the popularity of live streaming marketing, there are also some consumption traps, which not only harm the rights and interests of consumers but also affect its own development. Thus, how to build trust and improve the credit evaluation mechanism has become a common concern of academic and industrial circles. Anchored in the theory of planned behavior (TPB) and other research results, this paper expounds on the definition and connotation of trust intention in live streaming shopping in detail. From the perspective of consumers, the trust model of live streaming shopping is constructed based on the comprehensive consideration of social presence, consumers' personal attitude, and structural assurance. It adopts partial least squares (PLS) structural equation modeling (SEM) to evaluate the research model and hypothesis. On the basis of 259 samples, the result shows that consumers' trust behavior in live streaming shopping is mainly affected by live streamers' personalities, comment information, social presence, platform characteristics, usefulness, and structural assurance. The research result of this paper will play a positive role in building a more credible environment, improving the trust relationship with consumers, and promoting potential transactions. Meanwhile, it also lays a foundation for understanding consumers' trust behavior and related theories in the context of China.

*Keywords:* Trust, live streaming, online shopping, consumer behavior.

### INTRODUCTION

As of June 2021, the number of live streaming users in China had reached 638 million, with an annual increase of 75.39 million and accounting for 63.1% of total netizens (China Internet Network Information Center, 2021). Among them, the number of e-commerce live streaming users was 384 million, which raised 75.24 million compared with 2020 and took up 38.0% of all Internet users (China Internet Network Information Center, 2021). In addition to traditional e-commerce platforms, TikTok, Kuaishou, and other platforms had also expanded their investment to the e-commerce live streaming business in the first half of this year (Guan et al., 2021). In April 2021, TikTok said it would support its partners in service ability assessment training, multi-dimensional incentives, and the provision of professional tools. On May 20th, Kuaishou initiated the mid-year promotion campaign and jointly launched live streaming marketing shows with local TV stations, attracting a total of 236 million viewers. At the same time, the e-commerce live streaming business on traditional platforms has also maintained a progressive trend. According to the data, the cumulative live streaming marketing volume during JD's 618 promotion activity increased by 161% year on year, and the trading volume of Taobao live streaming in the first hour of June 1 exceeded that of the day of last year (China Internet Network Information Center, 2021).

We have witnessed a strong development momentum of e-commerce live streaming, but some problems also come into being in the process, such as live streamers' wrong words and deeds, data fraud, the frequent occurrence of fake and shoddy goods, and so on (Song & Liu, 2021). In addition, the interactive live streaming platform also offers consumers more opportunities to participate in social e-commerce, including online shopping activities. Users are no longer passive information recipients. Instead, they can influence the purchase behavior of other users through real-time feedback, comments, and recommending products to other people on the live streaming platform (Chen et al., 2020). A number of empirical studies point out that the building of consumers' trust behavior in the process of live streaming shopping will be a crucial basis for the completion of transactions (Luo et al., 2021; Zuo & Xiao, 2021). This research defines trust behavior as consumers' willingness to trust products or services based on the live streaming platform in the specific live streaming shopping situation.

The existing online shopping studies indicate that consumers will reduce the risk of their own behavior by referring to the behaviors and word-of-mouth opinions of other consumers (Marriott & Williams, 2018; Salam et al., 2003; Wang & Chang, 2013). A prominent characteristic of the live streaming marketing model is that consumers are placed in an interactive and virtual online shopping situation participated by others (Guan et al., 2021). The real-time interaction has qualitatively changed the decision-making environment of consumers and the traditional B2C e-commerce model (Chen et al., 2020). According to the theory of planned behavior (TPB), people's activities are often influenced by others (Ajzen, 1991). Scholars have found that consumers' behaviors and decisions tend to be affected by family members, friends, salespeople, and even strangers in society (Dellarocas et al., 2007). Anchored in the current research results, scholars' research on live streaming mainly focuses on information technology and the application of live streaming (Hsu, 2019; Liu et al., 2020). And some scholars also pay attention to the current situation analysis, platform technology research, communication analysis, and legal norms of live streaming shopping (Yu & Lo, 2020; Zuo & Xiao, 2021). However, there are few studies on consumers' conformity behavior caused by real-time interaction and social presence in the live streaming environment, notably trust behavior. Besides, much of the current live streaming research is limited to the theoretical level, and there are relatively few empirical research outcomes. Furthermore, there are fewer research results on the influencing factors of live streaming users' trust behavior around the representative groups in the context of China.

Therefore, this research proposes the following questions: what factors determine consumers' trust behavior in the live streaming shopping environment? How do these factors affect consumers' trust intentions? To answer the above questions, this paper decides to explore the influence mechanism of social presence, personal attitude, and structural assurance on trust behavior based on TPB. This will help solve the above problems.

Taking TPB as the theoretical reference, this research builds consumers' trust model in the live streaming shopping environment, analyzes 259 sample data collected by partial least squares structural equation modeling (PLS-SEM), and then tests the research model and hypothesis proposed in this paper. The results of this research show that consumers will show a strong conformity consumption tendency in live streaming, and their initial attitude will be significantly affected by the personality of the live streamer and social presence in the live streaming environment. At the same time, the structural assurance of live streaming software, such as the characteristics of the platform and the usefulness of the software or platform, will play a crucial supporting role in consumers' trust behavior. These results will help readers have an overall understanding of the composition and development of consumers' trust behavior in the context of Chinese live streaming so as to provide some theoretical reference for the relevant research in the future.

The research ideas and contents of this paper are arranged as follows: firstly, it combs and summarizes the studies and results related to living streaming shopping and online trust. Secondly, based on TPB and the trust model of related literature, it puts forward the framework of this research and constructs the corresponding research hypothesis. Then the questionnaire is designed according to the scale of the existing literature. The relevant data are collected through online questionnaires, and the research model and hypothesis are evaluated and tested by PLS-SEM. Finally, the corresponding research conclusions and theoretical and practical significance are put forward. Of course, the limitations of this research and the direction of future research are also explained in this paper.

### **THEORETICAL BACKGROUND AND HYPOTHESES**

Online trust is one of the primary reasons for consumers to participate in online trading activities. Scholars believe that the role of online trust is to improve the possibility of expected behavior, increase the predictability of behavior results, and reduce transaction costs (Wang & Emurian, 2005; Zhang & Zhang, 2005; Zhu et al., 2009). At the same time, online trust can also reduce the uncertainty of partners and speculation (Koufaris & Hampton-Sosa, 2004; Lim et al., 2006; Mou et al., 2017; Mukherjee & Nath, 2007; Wang & Emurian, 2005; Zhang & Zhang, 2005; Zhu et al., 2009). From the above research results, we can see that if enterprises can make consumers feel that online shopping is trustworthy, it will decrease consumers' perceived risk and uncertainty and contribute to the development of online transactions. Live streaming shopping can be viewed as a form of online shopping, and consumers' online trust will also have a significant impact on improving potential transactions (Lazaroiu et al., 2020; Rasty et al., 2021).

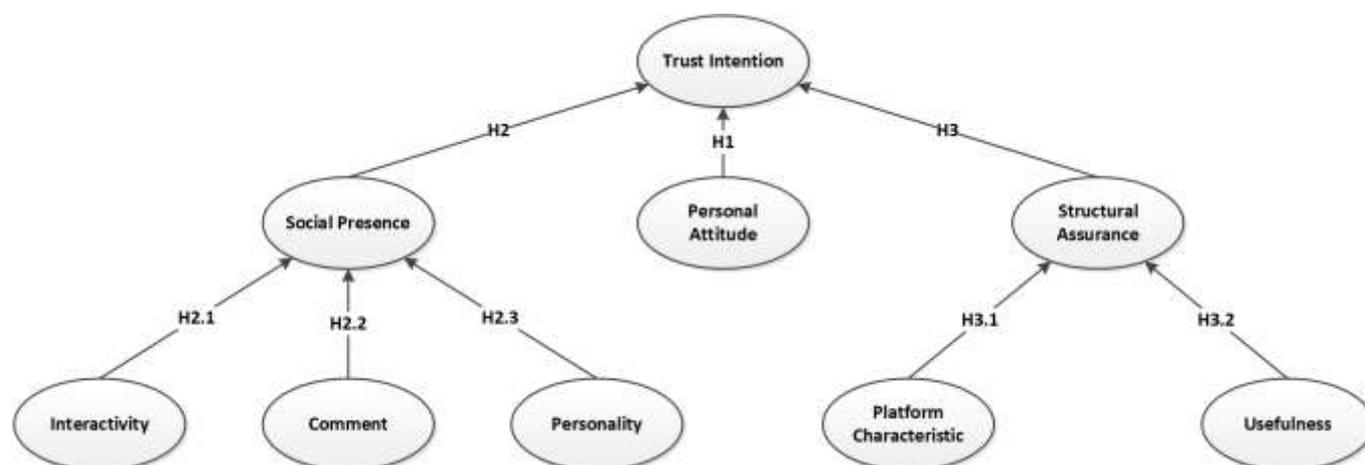
At present, few studies involve the trust behavior of live streaming shopping under the interaction of multiple factors from the perspective of consumers, and the relevant empirical studies are generally discussed from the personality of the live streamer. The current research shows that live streamers often serve as opinion leaders, and their recommended information is professional (Lim et al., 2020; Lu et al., 2018). Some scholars point out further that live streamers' behavior is interactive and attractive, which can make consumers have a pleasant and amusing shopping experience after buying and then increase consumers' added value in the process of purchase (Chen et al., 2020; Liu et al., 2020). However, it is undeniable that in the live streaming environment, high-frequency and forceful information transmission, as well as highly provocative language allow e-commerce live streamers to awaken consumers' purchase desire better.

As per the relevant research of psychology, the intrinsic state of consumers includes cognitive and emotional aspects (Hsu, 2019; Lazaroiu et al., 2020; Li, 2019). Cognition describes the intrinsic psychological process and state of consumers, including attitude and faith, while emotion has a tremendous influence on individual information screening and decision-making. Empirical research notes that the atmosphere of live streaming shopping will affect consumers' emotional and

cognitive states, thus affecting their purchase intention. The change of their emotions is more likely to affect impulse consumption (Lim et al., 2020; Meng et al., 2021).

Overall, the current research discusses the usefulness and accessibility of consumers' perception of live streaming platforms or software, as well as social media. It focuses on the impact of live streamers' personalities on consumers' online trust behavior. As a core component of live streaming marketing, the live e-commerce streamer highly restores the actual offline consumption situation with its own attributes, thus becoming the most influential spokesman of products or businesses and then continuously affecting consumers' online trust intention. However, the social expectation of individual consumers in the live streaming environment and the structural assurance of the live streaming environment will also cause a crucial impact on consumers' behavior. The empirical research in this area is insufficient. In particular, the current research rarely considers the joint action of the three factors.

TPB believes that any factor affecting behavior indirectly affects it by influencing attitude, subjective norm, and perceived behavior control (Ajzen, 1991). Concerning the trust problem of e-commerce, we can use this theory to research the relevant factors affecting consumers' behavior. Moreover, we can raise consumers' trust level by improving these factors and further promote potential consumers to produce actual purchase behavior. Most consumers are rational individuals. When they have time to think about the trust behavior they will perform, their behavioral intention will be the best way to examine trust behavior. According to the characteristics of the online live streaming environment, this research believes that trust intention is jointly determined by consumers' personal attitude towards trust behavior, social presence, and structural assurance, as shown in **Figure 1**. Social expectation represents the pressure perceived by a consumer about whether he should perform the corresponding behavior in the eyes of others. Structural assurance means whether consumers have the infrastructure or objective conditions to execute specific behaviors.



Source: This study.

Figure 1: A research framework.

According to TPB, a personal attitude refers to a person's positive or negative feelings when acting (Ajzen, 1991). An individual's attitude towards behavior is determined by his or her belief in the implementation of some behavior and the evaluation of the results (Sutanonpaiboon & Abuhamdieh, 2008; Walczuch & Lundgren, 2004). In the live-streaming shopping environment, consumers' personal attitude refers to a kind of subjective consciousness, which focuses on the possibility that the implementation of trust behavior will produce specific results. It can be predicted that a positive personal attitude will raise the intention of consumers' trust behavior. Thus, this study is hypothesized that:

**H1.** *Personal attitude has a significant positive impact on users' trust intention in live streaming shopping.*

Scholars define social presence in online shopping as a substitute for face-to-face communication (Cyr et al., 2007; Dash & Saji, 2008). As per their research, social presence can improve consumers' safety perception and purchase attitude in virtual shopping (Lu et al., 2016). Jiang et al. (2019) pointed out through research that the interactive characteristics of websites could promote consumers' social presence. Some scholars argue that social presence affects behavioral intention by affecting the sense of pleasure and usefulness (Hassanein & Head, 2007; Lu et al., 2016). In this paper, social presence refers to the extent to which live streaming media brings users a similar genuine offline shopping environment and the perceived degree of contacting others. Social presence significantly enhances the perception of online interpersonal interaction, which essentially turns personal consumption behavior into socialized consumption behavior. Therefore, this paper puts forward the following assumption:

**H2.** *Perceived social presence has a significant positive impact on users' trust intention in live streaming shopping.*

Interactivity can also be called real-time interaction, which means that consumers can communicate with information sources and feedback information and emphasizes the two-way dissemination of information (Men & Zheng, 2019; Xu et al., 2020). In the process of live streaming, in addition to receiving the live streamer's information, a consumer can also communicate with the live streamer or other consumers through "bullet chat." By sharing his/her shopping experiences and opinions, an atmosphere that everyone watches live streaming can be created to promote the group's purchase behavior. Interactive behavior can offer consumers positive feedback and enhance consumers' trust further. Hence, it is hypothesized that:

*H2.1. Perceived interactivity has a significant positive impact on users' trust intention in live streaming shopping.*

In the context of online shopping, consumers' trust usually depends on comment information to build (Liew et al., 2017; Malik & Hussain, 2020). However, due to the emergence of information overload and the existence of false comments, consumers often face difficulties in reading and screening helpful information (Cao et al., 2011; Fang et al., 2016; Liu et al., 2017). In the live-streaming shopping scenario, direct communication and contact with others can increase mutual trust. Consumers access information by chatting with others to enhance their sense of trust in other consumers' behaviors. Thus, the following research hypothesis is proposed:

*H2.2. Perceived comment has a significant positive impact on users' trust intention in live streaming shopping.*

E-commerce live streaming emphasizes sociality. Live streaming will make the virtual community environment become real. The personality of the live streamer enables consumers to establish an emotional bond with him/her, and the positive emotion makes consumers have a positive impression of the products recommended by him/her (Chen et al., 2020; Cheng, 2020; Hsu, 2019). The long-term interaction and accumulation make the live streamer more reliable, so consumers tend to believe that the goods or services they recommend are cheap and fine. Therefore:

*H2.3. The perceived personality of the live streamer has a significant positive impact on users' trust intention in live streaming shopping.*

Because consumers cannot grasp all the information about products and enterprises, they are likely to make wrong decisions and even give up transactions. At this time, if the enterprise can accurately transmit the signals containing its own advantageous information (such as convenient return and exchange policy, trustworthy qualification, and reliable after-sales service) to consumers, it can reduce the cost of consumers' information collection, lower their risk perception, promote the formation of trust, and may improve the ultimate transaction volume (Lu et al., 2018; Men & Zheng, 2019; Salam et al., 2003; Song & Liu, 2021). This research defines this positive signal transmitted by enterprises as structural assurance, that is, a protective mechanism or procedure to make consumers trust enterprises. It includes a guarantee, contract, regulation, commitment, legal aid, and so on. Hence, it is hypothesized that:

*H3. Structural assurance has a significant positive impact on users' trust intention in live streaming shopping.*

The live streaming platform used by consumers constitutes the basis of live streaming shopping, and the fear of unsafe and unreliable platforms is a significant reason why consumers do not trust this way of purchase (Chen et al., 2020; Cheng, 2020; Guan et al., 2021). The live streaming platform helps consumers form their cognition of commodities and allows consumers to have a general visual understanding through the goods presented on it. In addition, the platform enables the audience to understand the experience of other consumers via the interaction between the live streamer and the audience. The live streaming platform provides consumers with comprehensive information about commodities, helps consumers establish a complete commodity image, lowers consumers' risk perception, and enhances their purchase intention by building trust. Therefore, we propose the following hypothesis:

*H3.1. Platform characteristic has a significant positive impact on users' trust intention in live streaming shopping.*

In the process of online shopping, users' perceived risks are often offset by the potential benefits of convenience and accessibility provided by social websites. Users will evaluate the attractiveness of goods and services from different aspects, and perceived usefulness is a vital indicator (Koufaris & Hampton-Sosa, 2004; Zhu et al., 2009). Perceived usefulness reflects the extent to which users believe that the convenience and efficiency of shopping can be improved when conducting live streaming shopping. The current research suggests that perceived usefulness has a significant impact on personal use attitude. The more helpful users feel when using new technologies, the more positive they will become when using them. Therefore, this paper believes that:

*H3.2. Perceived usefulness has a significant positive impact on users' trust intention in live streaming shopping.*

## RESEARCH METHODOLOGY

The scale design in this questionnaire takes the mature scales in the relevant literature as a reference and makes appropriate modifications and adjustments based on the characteristics of live streaming shopping. In the initial scale, except for the basic information of the interviewees, other questions are measured by a 7-point Likert scale. Specifically speaking, the questions

are valued with 1-7, with 1 indicating strong disagreement while 7 indicating strong agreement. After the completion of the initial questionnaire design, a small-scale pre-test was conducted in relevant fields. A total of 30 questionnaires were collected to check if the semantic and grammatical expressions of the options in the questionnaire are easy to understand and if the reliability and validity meet the requirements. Meanwhile, some expressions of the questionnaire were modified according to the feedback of the respondents, and finally, a formal questionnaire was formed.

The questionnaires were mainly distributed online through the Qualtrics questionnaire survey tool, and a total of 287 questionnaires were collected. After excluding those questionnaires with excessively short answer time or over-concentrated selected options, 259 valid questionnaires were obtained. In addition, the most common rule for determining the sample size of PLS-SEM is the 10-fold principle. Therefore, in accordance with this principle, the minimal number of samples for this study is 90. The acquired data of 259 samples in this study could effectively improve the accuracy of PLS evaluation. As PLS-SEM imposes few limitations on the experimental data, this study decides to adopt this method to evaluate the research model and verify relevant assumptions. For instance, PLS features sound interpretation ability even in the case that the sample size is small. Besides, PLS has no requirement for the normal distribution of data. In addition, such an approach could handle the reflective & formative measurement model easily without the problem of identification.

The demographic characteristics of survey participants are shown in **Table 1**. Among all participants, men and women are distributed evenly. From the age structure of participants, the age group of the participants mainly concentrates at the range of 18-24, accounting for about 60% of the total. Moreover, most participants have received higher education, with about 56% of participants enjoying the undergraduate degree or above.

Table 1: The demographic profile of respondents (n=259).

Measure	Category	N	Percent
Gender	Male	132	50.97%
	Female	127	49.03%
Age	18-24	153	59.07%
	25-34	67	25.87%
	Over 35	28	15.06%
Education	College	115	44.40%
	Undergraduate	89	34.36%
	Postgraduate	55	21.24%

Source: This study.

## RESULTS

### Measurement Model

This study uses internal consistency reliability to test the reliability of each construct measurement method. As shown by **Table 2**, both the Composite Reliability (CR) and Cronbach's coefficient  $\alpha$  (CCA) of each construct are larger than 0.7, which indicates that the measurement of each construct in this study has sound reliability of internal consistency (Fornell & Larcker, 1981; Hair et al., 2012).

The construct validity of this study is mainly evaluated by content validity, convergent validity, and discriminant validity. As the scales of this study are adapted from the existing literature, they feature content validity. As shown by **Table 3**, the standardized outer loadings of all indicators in their construct are larger than 0.820, and the Average Variance Extracted (AVE) of different constructs is larger than 0.5 in **Table 2** (Barclay et al., 1995; Chin & Newsted, 1999). Therefore, all constructs have sound convergent validity. As shown by **Table 4**, the square root of the AVE of any construct in the model is greater than the corresponding correlation values with other constructs. Moreover, as shown by **Table 3**, the standardized outer loadings of all indicators in their belonging constructs are larger than their cross-loadings. Such indicates that the measurement of different constructs in this study has sufficient judgment validity (Fornell & Larcker, 1981; Hair et al., 2012).

Table 2: The descriptive statistics for the constructs.

	Items	CR	CCA	AVE
Trust Intention (Inten)	2	0.956	0.908	0.916
Social Presence (Prese)	3	0.926	0.880	0.807
Personal Attitude (Attit)	3	0.950	0.921	0.863
Structural Assurance (Assur)	3	0.955	0.929	0.876
Interactivity (Inter)	3	0.964	0.944	0.899
Comment (Comme)	3	0.951	0.924	0.867
Personality (Perso)	3	0.928	0.884	0.812
Platform Characteristic (Platf)	3	0.970	0.954	0.916
Usefulness (Usefu)	3	0.982	0.972	0.947

Source: This study.

Table 3: The factor loadings and cross-loadings.

	Inten	Prese	Attit	Assur	Inter	Comme	Perso	Platf	Usefu
Inter.1	<b>0.997</b>	0.355	-0.107	0.118	0.345	-0.457	0.558	0.168	-0.106
Inter.2	<b>0.964</b>	0.332	-0.190	0.135	0.354	-0.434	0.531	0.213	-0.071
Inter.3	<b>0.901</b>	0.363	-0.174	0.115	0.346	-0.439	0.573	0.149	-0.113
Perso.1	-0.275	<b>0.890</b>	-0.573	0.113	0.544	-0.506	0.403	-0.273	-0.085
Perso.2	-0.240	<b>0.868</b>	-0.532	0.123	0.523	-0.464	0.485	-0.249	-0.098
Perso.3	-0.209	<b>0.821</b>	-0.541	0.058	0.515	-0.470	0.415	-0.360	-0.122
Attit.1	0.159	-0.104	<b>0.928</b>	0.072	-0.379	0.213	-0.576	-0.035	0.237
Attit.2	0.144	-0.152	<b>0.926</b>	0.060	-0.387	0.219	-0.547	-0.087	0.227
Attit.3	0.136	-0.149	<b>0.933</b>	0.077	-0.357	0.247	-0.572	-0.048	0.191
Assur.1	0.304	0.045	0.046	<b>0.940</b>	0.133	0.078	0.119	0.533	0.634
Assur.2	0.326	0.026	0.123	<b>0.928</b>	0.085	0.127	0.098	0.485	0.630
Assur.3	0.324	0.044	0.045	<b>0.940</b>	0.143	0.110	0.087	0.564	0.638
Inter.1	-0.497	0.355	-0.207	0.118	<b>0.945</b>	-0.457	0.558	0.168	-0.106
Inter.2	-0.464	0.332	-0.290	0.135	<b>0.954</b>	-0.434	0.531	0.213	-0.071
Inter.3	-0.401	0.363	-0.274	0.115	<b>0.946</b>	-0.439	0.573	0.149	-0.113
Comme.1	0.520	-0.252	0.631	0.115	-0.395	<b>0.934</b>	-0.483	0.143	0.294
Comme.2	0.556	-0.296	0.641	0.104	-0.460	<b>0.941</b>	-0.523	0.148	0.266
Comme.3	0.494	-0.277	0.612	0.095	-0.447	<b>0.919</b>	-0.479	0.114	0.192
Perso.1	-0.375	0.190	-0.573	0.113	0.544	-0.506	<b>0.903</b>	-0.273	-0.085
Perso.2	-0.340	0.168	-0.532	0.123	0.523	-0.464	<b>0.885</b>	-0.249	-0.098
Perso.3	-0.309	0.121	-0.541	0.058	0.515	-0.470	<b>0.915</b>	-0.360	-0.122
Platf.1	0.448	-0.252	-0.073	0.536	0.200	0.157	-0.323	<b>0.961</b>	0.365
Platf.2	0.449	-0.263	-0.049	0.539	0.161	0.134	-0.296	<b>0.950</b>	0.329
Platf.3	0.456	-0.257	-0.052	0.544	0.172	0.125	-0.322	<b>0.960</b>	0.364
Usefu.1	0.423	-0.143	0.221	0.680	-0.097	0.261	-0.087	0.353	<b>0.976</b>
Usefu.2	0.431	-0.173	0.257	0.651	-0.124	0.267	-0.126	0.336	<b>0.975</b>
Usefu.3	0.416	-0.147	0.210	0.645	-0.079	0.256	-0.120	0.388	<b>0.969</b>

Notes: Bold numbers indicate item loading on the assigned constructs.

Source: This study.

Table 4: The correlation between the dimensions.

	Inten	Prese	Attit	Assur	Inter	Comme	Perso	Platf	Usefu
Inten	<b>0.957</b>								
Prese	-0.547	<b>0.898</b>							
Attit	0.496	-0.512	<b>0.929</b>						
Assur	0.340	0.041	0.075	<b>0.936</b>					
Inter	-0.620	0.486	-0.434	0.129	<b>0.948</b>				
Comme	0.563	-0.297	0.674	0.112	-0.468	<b>0.931</b>			
Perso	-0.549	0.670	-0.408	0.108	0.585	-0.532	<b>0.901</b>		
Platf	0.471	-0.269	-0.061	0.464	0.186	0.145	-0.328	<b>0.957</b>	
Usefu	0.435	-0.158	0.235	0.377	-0.103	0.268	-0.114	0.369	<b>0.973</b>

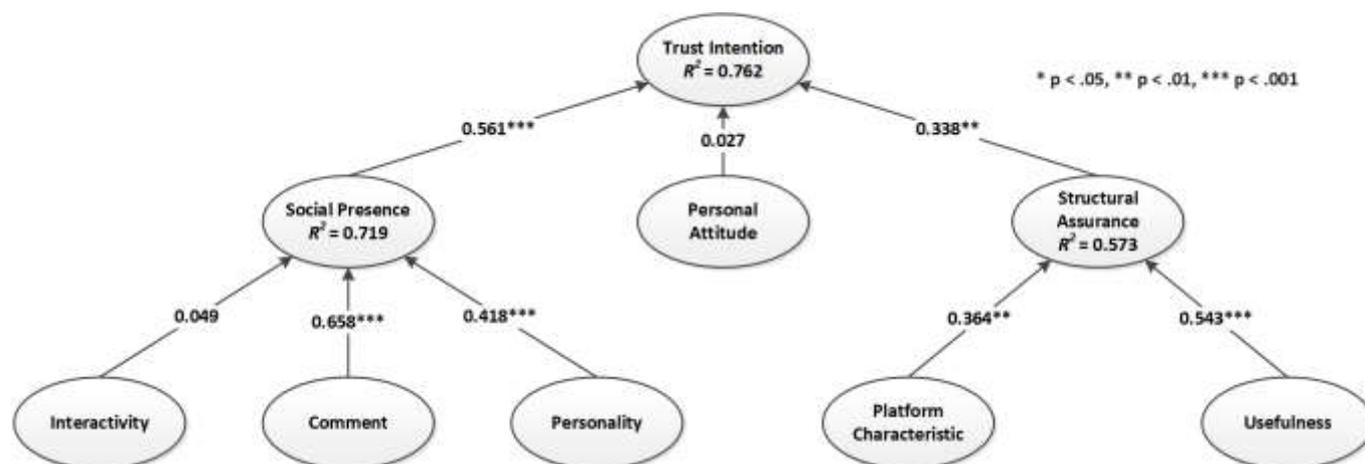
Notes: Boldface values on the diagonal are the square root of the AVE.

Source: This study.

### Structural Model

This study tested the statistical significance of the t-value for the path coefficient in the research model through bootstrapping in SmartPLS 3.3.3. The number of original samples is 259. According to the general recommendations of PLS research, this paper set the bootstrap subsamples as 5000. The path coefficient and statistical significance test results are shown in **Figure 2**. Among the eight assumptions raised by this paper, six assumptions passed the statistical significance test. The empirical results show that live streamers' personalities, other consumers' comments, platform characteristics, usability, social expectation, and structural guarantee would exert significant influences on the generation of consumers' trust in the live streaming shopping environment. Besides, this study points out that the interaction with live streamers and consumers' personal attitudes at the very beginning does not have a significant influence on their trust behavior. At last, this research finds out that different factors

have different influences on consumers' trust in live streaming shopping. Among them, the comments are the most influential ones, followed by the social presence, usefulness, personality of live streamers, and platform characteristic.



Source: This study.

Figure 2: PLS-SEM analysis results.

The coefficient of determination ( $R^2$ ) is the most commonly used coefficient in evaluating the structural model, which is used to evaluate the prediction ability of the model (Chin & Newsted, 1999).  $R^2$  falls between 1 and 0. The higher the value it is, the greater the prediction ability would be. In general, when  $R^2$  lies between 0.5-0.75, the interpretation ability is moderate. If  $R^2$  is higher than 0.75, it means it has significant interpretation ability (Hair et al., 2012). In this study, the  $R^2$  of the consumers' trust intention reaches a relatively high level of 0.762, which indicates that the model raised in this study has a good interpretation ability.

## DISCUSSION AND IMPLICATION

### Summary of Results

Based on the TPB and existing research results, this paper first expounded the definition and connotation of trust intention in live streaming shopping. Then, from the perspective of consumers, based on a comprehensive consideration of social presence, consumers' personal attitudes, and structural guarantees, it constructed a trust model for live streaming shopping. PLS-SEM was used to evaluate the research model and hypothesis. According to the survey of 272 samples, the results showed that consumers' trust behavior in live shopping is affected by various factors, mainly including anchor characteristics, information of comments, social presence, platform characteristics, usefulness, and structural guarantees. Moreover, the study also found that in the context of live streaming shopping, consumers' initial personal attitudes and their interactions with the anchor do not have a significant impact on their trust.

Based on the results of this empirical study, it can be concluded that live marketing is actually a type of trust-based marketing in a sense, and it is quite crucial to establish and maintain trust. In many cases of live streaming marketing, for the phenomenon of "instant sell-out," the consumer's trust in the anchor plays a crucial role. The establishment of such a trust is not a day's work but is the result of long-term efforts to cultivate. Therefore, to win the lasting popularity of consumers in live broadcast marketing, the key point is to establish a solid trust foundation with consumers. From this perspective, for live broadcast marketing, only by using trust as a link and fully straightening out the relationship among platforms, anchors, merchants, and consumers, can the market continue to inspire vitality.

Through the e-commerce platform, live streaming shopping can provide consumers with a shopping experience similar to that of physical stores (Chen et al., 2020; Liu et al., 2020). When watching the live broadcast, people can get authentic and detailed information about the product at any time, and ask the seller questions in real-time, or even communicate with other viewers. More importantly, consumers can also view the results of online product trials. Therefore, based on the characteristics of the live broadcast platform and consumers' perception of its usefulness, consumers' trust in live streaming shopping can be enhanced.

With the development of Internet technology, sellers are allowed to present their products in detail by publishing text and pictures. However, sometimes consumers still may not be able to obtain comprehensive information, which greatly increases the cost of consumers' judgment and decision-making. Then, the emergence of streaming media technology can solve this problem to some extent because it can realize live broadcast and video playback (Song & Liu, 2021; Xu et al., 2020). The products displayed by the seller in the video are all authentic, without any deliberate editing. The application of live broadcast technology also allows sellers and consumers from different spaces to gather in a virtual space, imitating the shopping scene of physical stores. The camera used by the seller to make the video can be regarded as eyes for consumers. Generally, consumers are more inclined to accept what they see than what the seller tries to tell them.

In the live broadcast, sellers display more information than traditional pictures and text. Moreover, through the anchor's verbal rendering and expression suggestion, as well as marketing methods such as time-limitation, quantity-limitation, and high cost-effectiveness, it creates shopping scenes with real atmospheres. By demonstrating the personal characteristics of e-commerce anchors and relying on the impact and authenticity of contextual factors, consumers' trust in online live shopping can be greatly improved (Lu et al., 2018; Luo et al., 2021; Men & Zheng, 2019).

Real-time interaction is another major feature of live streaming shopping (Liu et al., 2020; Men & Zheng, 2019; Zhang & Zhang, 2005). In the live broadcast, consumers can ask questions at any time, which is a continuation and upgrade of online communication between buyers and sellers. Through live broadcast, sellers not only create fun for consumers but also improve the effectiveness of communication and avoid misunderstandings caused by textual communication. Moreover, when buyers see that their questions are answered by sellers on the screen, it is conducive to increase their trust and acceptance in the information replied. However, the data analysis results of this study also indicated that consumers are more inclined to trust other buyers than sellers because usually, there is no conflict of interest between consumers. Generally speaking, before making a purchase decision, consumers are more inclined to search and refer to other consumers' comments. At the same time, consumers can interact in real-time. It means that when someone comments on a product, real-time interaction will prompt consumers to quickly share more details about the comment, which provides potential buyers with more comprehensive and reasonable references, rather than the simple response of "Good" or "Bad." In that way, the authenticity of user feedback is improved, and the level of trust intent of potential consumers is enhanced, thereby reducing the risk of their perception of unknown products.

On the other hand, sellers can actively encourage consumers to participate in live broadcast interactions by playing games and handing out red envelopes so as to enhance consumers' favorable impression of them. Although this type of interaction can bring closer the relationship between the anchor and the consumer, most consumers still tend to maintain a sober and rational attitude. Consumers enjoy maintaining good interaction with sellers, but at the same time, they still focus on the quality and value of the products instead of blindly following the seller's guidance.

### **Implication for Theory**

The e-commerce industry is continuously developing. While providing consumers with a convenient online shopping environment, the entire industry also strives to eliminate various drawbacks as being compared with physical store shopping, such as trust issues. Therefore, relying on live broadcast technologies, e-commerce platforms strive to simulate the advantages of physical store shopping, such as providing the product details display, online product trials, and real-time communication with sellers. More importantly, some services they provide are not even available in physical stores. For example, potential consumers can discuss and exchange information with dozens or even hundreds of buyers. Based on the theory of planned behavior and previous research results, through the method of empirical research, this paper explored the construction process of consumers' truest intentions and behaviors in live shopping. The relevant research results are intended to lay a meaningful foundation for a deeper understanding of consumer behavior, as well as to promote the development of related theories.

In previous studies, the researchers investigated the current status of live stream shopping and also analyzed the platform's technologies, the dissemination of information, and the e-commerce environment and legal status. However, there are few detailed discussions on the herd behavior caused by factors such as real-time interaction and social presence in the live broadcast environment. In particular, there are few studies on trust behaviors. Based on an attempt to synthesize various influencing factors, this research attempted to present the factors that affect consumers' trust intentions with a complete system structure. The result is intended to provide a more comprehensive perspective for understanding the trust behavior in live broadcasts. In addition, this study further explored the specific impacts of various factors on consumer behavior and expounded the differences of these impacts. It is considered to be helpful for researchers to further understand the internal mechanism of social presence and trust construction.

### **Implication for Practice**

In recent years, the prevalence of live broadcasts has broadened the marketing channels of commodities to a certain extent and has driven economic development. The types of commodities involved in live broadcast marketing continue to increase. From food and daily necessities at the initial stage to the current real estate and automobiles, live broadcast marketing is in a period of ascent. With the increasing popularity, some consumption traps have also appeared in live broadcast marketing, which infringes on the rights and interests of consumers and hinders the healthy development of the industry. No matter how the technology is iterated and the channels are renewed, live streaming marketing is still a sort of marketing behavior, and it is supposed to adhere to the value orientation of integrity management. Correspondingly, based on the results of this empirical study, it proposed that sellers should disclose product or service information comprehensively, truthfully, and accurately, seriously perform related responsibilities, strictly control the quality of live products and services, and actively perform after-sales services in accordance with laws and regulations. In order to achieve the healthy development of the online live shopping industry, enterprises should adhere to the basic principles of integrity management. In this regard, it is necessary for all parties in the society to unite their efforts for coordinated governance. To this end, it requires the live broadcast platform to strengthen content review and improve the integrity evaluation mechanism. At the same time, the relevant regulatory authorities are supposed to severely crackdown on false marketing activities and increase the cost of infringement. The positioning of live broadcast marketing has never been a "one-time deal." Only by focusing on consumers' evaluation and their own reputation,

improving the quality of the platform, and establishing effective anchor personal characteristics can the entire industry achieve long-term development.

### Limitations and Future Research

Although this study makes a beneficial discussion on the factors affecting consumers' perception and trust in the live streaming shopping environment, it suffers inherent limitations. It is necessary, therefore, in a future study to make further improvements. To begin with, the number of samples investigated in this study is 259. It satisfies the requirements of PLS-SEM on minimal sample size, but the larger sample size could enhance the accuracy of the study and evaluation by the model effectively (Barclay et al., 1995; Chin & Newsted, 1999). Then, over the process of this empirical study, it does not consider the function of product types and cultural differences in adjusting the trust behaviors of consumers. Some existing frontier researches pointed out that the difference in product type might change consumers' information processing approach. Therefore, the future study shall analyze the function of product type and cultural difference in adjusting the trust behavior of consumers in live streaming shopping in order to further enrich the results of this study.

### CONCLUSION

At present, the scale of Chinese netizens continues to expand, the application penetration in various scenarios is accelerating, and the opportunities and advantages of digital consumption are prominent. On the one hand, the popularization of information technology has created convenience for consumers to access the Internet anytime and anywhere. On the other hand, new shopping methods represented by online live broadcast marketing have penetrated into consumers, and a variety of live broadcast applications have become important tools and are gradually accumulating commercial values. Only in the first half of 2021, short video, live broadcast, and e-commerce achieve mutual benefits, and platforms such as Kuaishou and Tik Tok have become important battlefields of e-commerce (China Internet Network Information Center, 2021). The online live broadcast is developing based on building the trust of potential consumers, relying on users and e-commerce content creators as the core, and establishing a trust relationship with users through the continuous content output of creators, so as to achieve the accumulation of traffic and increase the conversion rate of the e-commerce industry.

Compared with the characteristics of individual purchasing behavior in traditional consumption models, live streaming shopping actually reflects the public's inherent needs for social interaction and group affiliation during consumption (Chen et al., 2020; Guan et al., 2021; Luo et al., 2021). The dominance of live marketing depends not only on the innovation of business models but also on the understanding of consumers as human beings. With the continuous development of Internet technology and the e-commerce environment, consumers' expectations for live shopping have also shown a trend of individuation and customization. Therefore, it is necessary to adjust the transmission path of the mechanism that affects consumer trust and shopping intention in a timely manner. The current theoretical research mainly explored the impact of live shopping on consumers from the technical level, but there are still many issues worthy of attention on the level of individual trust behavior. Based on the method of empirical research, this paper used PLS-SEM to evaluate the research model and hypothesis. The research results showed that consumers' trust behavior in live shopping is mainly affected by anchor characteristics, information of comments, social presence, platform characteristics, usefulness, and structural guarantees. The research results of this paper are considered to be of a positive effect on enterprises building a more credible environment, improving trust relationships with consumers, and promoting potential transactions. Furthermore, it also laid a foundation for understanding consumer trust behavior and related theories in a specific context in China.

### ACKNOWLEDGMENT

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## Research on the Development Status and the Trend of Smart Home

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### ABSTRACT

The emergence of the Internet of Things (IoT) technology provides new directions and contents for the development of smart homes, breaks the time and space barriers between people and home systems, and the application of IoT technology realizes the integration and management of information between smart home devices, prompting people's home life to be safe, comfortable and intelligent, exploring the life needs of contemporary users, and building a harmonious relationship between people and smart home systems. At present, smart home is developing rapidly and has a greater impact on people's home life. This paper will elaborate on the development status of smart homes in the context of the Internet of Things and explore and study the significance and development trend of Internet of Things technology in the field of the smart home.

*Keywords:* Internet of Things, smart home, development status, trend.

### INTRODUCTION

The Internet of Things (IoT) is an extension of the Internet that enables connection, interaction, and Internet functionality between different devices or physical objects. With the rapid growth of IoT devices and applications in recent years, the IoT has played an important role in reducing human workload. In the IoT environment, all devices in our daily lives can be associated with the Internet through their computing and communication capabilities. While the debate continues about the depth of impact and adoption of IoT technologies in the coming decade, it is clear that the penetration of IoT in many areas is rapid and subversive. One emerging area examined in this paper is the application of IoT in the smart home.

The smart home is one of the key components and applications of the Internet of Things (IoT). It is an advanced technology which is helpful in people's daily life. A smart home uses IoT technology to connect various IoT-based household devices, security devices, and communication devices with the home intelligence management system, and the collected data information is processed through cloud computing, digital information recognition, and other technologies, and finally transmitted to the user's mobile terminal. The system provides personalized and diversified services for people, making the inside and outside of the house effectively connected. Users can easily monitor and control all home devices/appliances through the Internet, and these home devices are connected to the Internet using the appropriate network architecture and standard protocols. The advantage of this technology is that it will reduce the workload of people and provide users with security, comfortable living, and energy management. Through IoT-based smart home technology, all smart home devices can communicate with each other whenever and wherever, so as to realize the information interaction between people and things, things and things, to meet people's different needs. At this stage, IoT technology has been deeply used in smart homes, with increasingly stable performance and more efficient control. IoT technology is used to put forward innovative concepts and exponential development for smart homes, breaking the limitations of space and time, which can bring more convenience of life while satisfying users' needs and becoming the mainstream direction of current home development.

In recent years, people's interest in smart home systems has been increasing day by day. Smart home automation systems describe and record the status of connected home devices with an intuitive and user-friendly interface so that users can communicate, monitor, and remotely control different devices with simple operation. Bluetooth, Wi-MAX, Wireless LAN (Wi-Fi), ZigBee, and global system for mobile communications (GSM) are the main communication technologies used in today's smart home systems.

### THE INTERNET OF THINGS AND SMART HOME

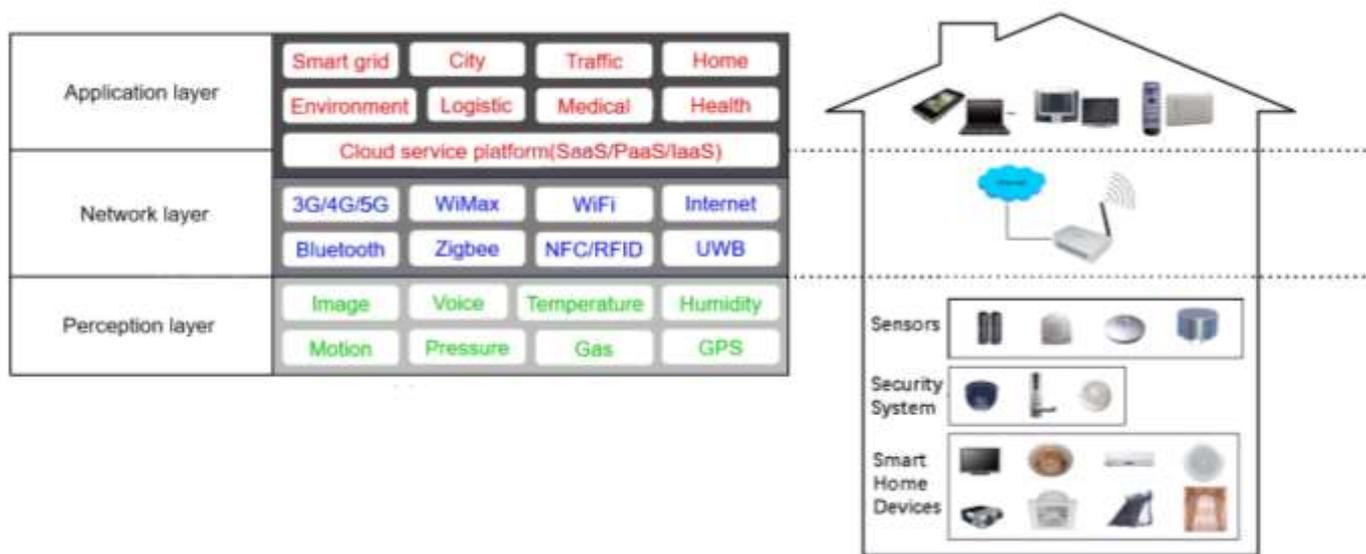
Technically, the realization of IoT functionality requires the integration of multiple technologies in terms of perception, network, and application. Therefore, the basic architecture framework of IoT can be divided into three major levels: perception layer, network layer, and application layer (Figure 1).

Perception layer - sensing information. The perception layer is the underlying and foundation of IoT, mainly addressing the core capability of comprehensive perception of IoT. It is composed of various sensors, security systems, smart home devices, etc. The role of the perception layer is equivalent to nerve endings such as human eyes, ears, nose, throat, and skin, etc. Its task is to identify objects and collect information so as to realize the awareness and perception of " objects. " For example: in the modern smart home, temperature and humidity sensors are widely used to intelligently measure indoor and outdoor temperature, so that people can know the temperature value, so as to facilitate travel and home.

Network layer. It is a converged network based on the existing communication network and the Internet. The network layer is connected with the mobile communication network and the Internet through various access devices, moving the collected data to the applications. It is equivalent to the human nerve center and brain, which is responsible for transmitting and processing the information obtained by the perception layer. In a smart home, each device operates independently of the other and communicates using a local network, with the home gateway acting as the access point, so that smart home users can remotely monitor, control, and manage household appliances or sensors.

The application layer is the interface between the IoT and users (including people, organizations, and other systems), based on collection and interconnection, which provide rich and specific services to users using analyzed and processed sensory data. In the smart home, a wide range of application solutions can be implemented through mobile phones, computers, and other terminals, specifically in the form of interactive behaviors between products and users. The application layer is the purpose of IoT development.

The application of IoT technology connects various smart home products together to achieve rapid integration and management of information, and through different combinations, different smart home systems can be built, such as elderly monitoring systems, child companion systems, home theater systems, etc.



Source: This study.

Figure 1: Smart home system structure.

## DEVELOPMENT STATUS OF SMART HOME

In the age of intelligence, with the continuous development and progress of society, people pay more and more attention to the quality of personal home life, and the market of smart home products has a broad prospect. A smart home is the use of modern science and technology and integrates life-related equipment in order to achieve the purpose of systematic and efficient management of family affairs. The safety, convenience, comfort, and artistry of the home can be greatly enhanced, and the requirements of energy-saving and environmental protection can be achieved. Smart homes not only require a high degree of intelligence of each individual facility but, more importantly, integrate individual devices into system control to create the effect of  $1 + 1 > 2$ . With the development of IoT technology and the improvement of product intelligence, the smart home system will provide more appropriate and considerate services for users.

### Smart Home Devices

After the application of Internet of Things technology in smart homes, a range of new smart home devices has emerged. At present, there are many smart home products in the market, such as Xiaomi's Yeelight smart light bulb and bedside lamp (Figure 2), iHealth smart blood pressure meter, smart bracelet (Figure 3), smart weight scale, smart air purifier, and some smart door lock, smart switch, smart curtain, etc. Most of them are controlled by mobile phones through IoT technology, and most of them are independent single, smart products. Voice system, as one of the most basic interaction functions, has been implanted in most of the smart products in the market, such as smart speakers, smartphones, smart voice control systems for cars, floor-sweeping robots, etc. In 2019 smart speakers were introduced for use as one of the smart home devices in most residents' homes. The elderly at home are able to communicate with people who are not around through a smart speaker with a screen, which can meet the spiritual needs of some elderly people living alone. When the smart speaker is connected with other home appliances, the elderly are able to control them by voice. Moreover, this kind of smart speaker also has the functions of checking the weather, playing music on-demand, and consulting. With the introduction of IoT technology, data can be stored and managed among multiple products. The development of this technology builds a harmonious bridge between people and products and truly achieves "contactless interaction." For example, the Xiaomi speaker, which allows users to control the work of the sweeping

robot by giving voice commands to it (Figure 4). Stryker IBed (Figure 5) with embedded alarm systems and other technical communication features can help patients interact with their caregivers. It is compatible with many third-party systems, iBed Wireless currently works with leading suppliers of EHR, Nurse Call, Middleware, Alert Management, and handheld devices (Figure 6).



Source: Baidu pictures.  
Figure 2: Yeelight smart light.



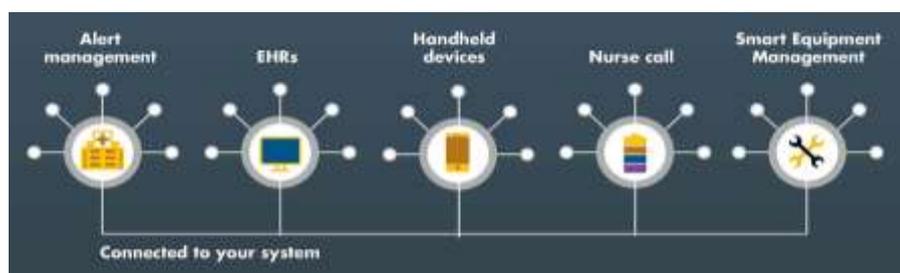
Source: Baidu pictures.  
Figure 3: Smart bracelet.



Source: Baidu pictures.  
Figure 4: Sweeping robot.



Source: <https://www.stryker.com>.  
Figure 5: Stryker IBed.



Source: <https://www.stryker.com>.  
Figure 6: Flexible connectivity of Stryker IBed.

### Smart Home Security System

The interconnectedness of the Internet means that Internet resources can be attacked from anywhere in the world, which makes network security a key issue. Smart home products take home as the core use scene, and the specificity of the use scenario determines that users have high requirements, high sensitivity, and high concern for product safety issues. Once there are security problems in smart home products, it will threaten the privacy, property, and life safety of users. Many experts have conducted various research on the security system of a smart home (Table 1).

Table 1: Research on the characteristics of a smart home security system.

Characteristics	definition	Author	Security Framework	Security Goals
Confidentiality	Confidentiality refers to keeping data private so that only authorized users (both human and machine) can access that data. Cryptography is the key technology for achieving confidentiality. There is a need to protect original information and sensitive information from being leaked to adjacent networks or even external networks	Zegers et al. (2015)	The protocol protects data before it is transferred to the cloud by separating key encryption from data encryption	It improves the flexibility and efficiency of encryption key management.
		Park et al. (2014)	For creating virtual activities against bypass attacks in a virtual home environment	Flexibility in controlling the amount of false data transmission to allow for trade-offs between energy efficiency and privacy protection.
Integrity	Integrity is an important security factor in the smart home. An attacker can change the original message by inserting some false information fragment into the transmitted message, or insert malware application, or change the service destination through malicious code. Therefore, integrity mechanisms are important to protect the original data from external attacks	Kang et al. (2017)	An internal security framework of smart home devices is proposed, which uses self-signature and access control technology	Provide security services to ensure device authentication, data integrity and availability, and prevent security threats such as data modification, leakage and code forgery.
Authentication	Authentication is necessary any IoT-based application; it usually deals with simulated threats. In smart home environment, it is essential to implement authentication to prevent illegal use of devices and systems. Authentication is the verification that the data has not been tampered with, and the main purpose is to verify the identity of the device user and prevent illegal users from operating smart home devices.	Kumar et al. (2015)	Lightweight security key establishment scheme	The scheme allows each device to perform lightweight mutual authentication before joining the home network, and uses a short authentication token to establish a security key, which needs to be stored in the home gateway
		Santoso et al. (2015)	Authentication using asymmetric elliptic curve passwords on traditional wifi networks based on the AllJoyn framework	Verify communication between IoT devices and provide users with the means to set up, access and control the system through Android-based mobile devices running appropriate applications
Access	Access refers that only properly authorized users are allowed to access data, communication infrastructure and computing resources, and ensure that these authorized users are not prevented from such access. To protect against potential attackers, each user and each device needs to be identified so that security policies can be implemented. Access to sensitive data should be controlled to avoid illegal access by third parties. Authorization mechanism is used to control the access to network services and sensitive resources by authenticated entities in smart home environment.	Lee et al. (2017)	The system uses Linux to isolate each function of the device, and grants the access to each required function	The access control system based on device function is called FACT, which can achieve more fine-grained access control. Control the access to sensitive information
		Rahmati et al. (2018)	Risk-based access control of permissions	Group device operations according to the risk similarity, and grant corresponding access rights by group The scheme can significantly reduce the security risk.

Source: This study.

### Smart Home Whole-house System

The smart home whole-house system (Figure 7) mainly consists of a lighting control system, electrical control system, environmental control system, and central control management system. Each system can operate independently, realizing the

intelligence of living scenes and making corresponding feedback according to the changes of the environment and user behavior habits.



Source: Baidu pictures.

Figure 7: Smart home whole-house system.

The German company OTB has installed a collection of smart assistive devices for the elderly in a nursing home apartment, providing the home facilities needed for independent living elderly, as well as monitoring the physical condition of the elderly in the nursing home through smart device data and responding to emergencies in real-time. For example, remote control of bed lifting, pre-alarm sensor mattresses, under-bed sensor blankets, and automatic meal feeders, etc., can help the elderly live independently and have a certain degree of safety. The German company OTB is at the forefront of smart product innovation in the design of the whole-house smart home.

In recent years, there have been new breakthroughs in smart home design in China. For example, in an apartment for the elderly, intelligent home systems such as emergency call, intelligent environment, intelligent nanny, intelligent night, sleep monitoring, intelligent curtain, intelligent window, intelligent air conditioner, IoT door lock, etc. are installed in the rooms to connect basic home devices and electrical appliances, and build an interconnected home network through IoT, cloud computing, voice recognition, and artificial intelligence technologies, freeing the hands of the elderly and allowing the elderly with mobility or visual impairment to operate various home appliances easily. Among them, the emergency call and intelligent positioning system can locate various actions and conditions of the elderly, and give an emergency alarm, which can quickly give feedback on the occurrence of emergencies and improve processing efficiency; The intelligent environment control system senses the environment through sensors, monitors the formaldehyde, dust, temperature and humidity of the home environment in real time, uses the device controller to respond, automatically opens the windows or fresh air or air purifiers, and adjusts the indoor temperature and humidity value according to the changes of the environment, so as to create a suitable environment for users to live in; Intelligent nursing mode can detect various physical values of the elderly, as well as help the elderly to adjust a reasonable diet, remind meal precautions, and ensure all-round safety and health; The intelligent lighting system can turn on or off the lights through voice operation, which reduces the complexity of switching operation, and can automatically turn off the lights at home when there is sufficient daylight, in addition, when it detects that the elderly get up at night, it can automatically turn on the lights in bathroom and corridor through voice command or human body sensor to avoid bumping and falling due to dim light, which reflects the ability of identifying and judging information of smart home, aiming to maximizing the comfort of the residents and hopefully providing some service support for the elderly with limited mobility.

### DEVELOPMENT TREND OF SMART HOME

At present, there are still various problems in smart home products, which cannot meet people's higher demand for smart products. In the process of future development, the smart home will evolve gradually with the continuous collection and analysis of big data and the continuous progress of science and technology so as to continuously improve the intelligence level. With the rapid development of IoT technology, many families have started to use the smart home system. Applying IoT technology to a smart home can make people have a better life experience and feel the convenience and speed provided by a smart home.

#### Improve Security

Security is the basic premise and guarantees to improve the quality of life and future development and progress (Figure 8). As a resource-sharing technology, IoT technology can be connected with multiple users, which provides people with a good living experience, but at the same time, there are also various problems, such as exposing their privacy and providing opportunities for illegal personnel. In the process of designing the smart home, designers need to comprehensively consider user privacy and smart home security and need to deal with various risk factors, such as smoke detectors to prevent residential fire, infrared detectors at

the main entrances and exits to prevent burglaries, and smart cameras to help users keep track of their home and family members' activities. These smart security devices (Figure 8) cooperate with each other to quickly provide users with information about their homes, improving the quality of life for people while providing a more comprehensive approach to home security. The introduction of smart products greatly enhances the emergency risk-avoidance mechanism required by users to understand and solve problems as soon as possible. Many experts have carried out a variety of research (Table 2).



Source: Baidu pictures.  
Figure 8: Smart home security system.

Table 2: Research on smart home safety.

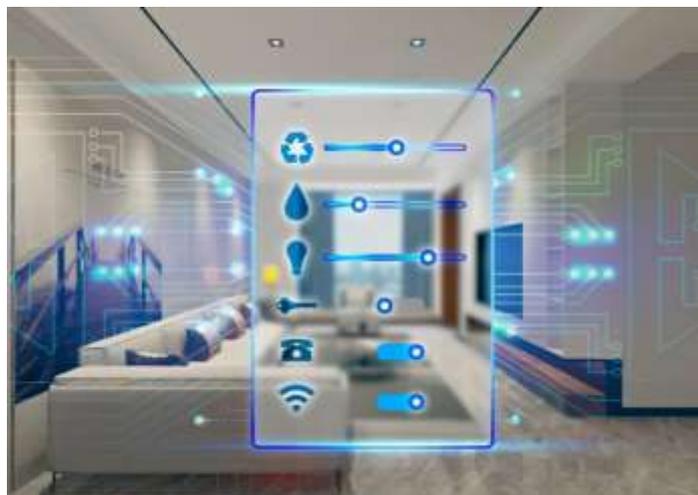
	Author	Significant Aims
Monitor	Jabbar et al. (2018)	<ol style="list-style-type: none"> <li>1. Smart home (SH) automation system uses Arduino Mega microcontroller to build robot system.</li> <li>2. Sensors are used to show humidity, temperature, and movement in the house.</li> </ol>
	Zandamela (2017)	<ol style="list-style-type: none"> <li>1. Send real-time video information, detect fire, movement, and intrusion, monitor humidity, and temperature.</li> <li>2. The system has an excellent interconnection, low power consumption, low price, high precision, real-time monitoring, and strong anti-interference performance.</li> </ol>
Remote monitor and instant control of household devices	Adiono et al. (2017)	<ol style="list-style-type: none"> <li>1. Both the RSA and EAS algorithm is utilized for encoding the entire data communication.</li> <li>2. Control the home devices dynamically and intelligently according to activities and instructions.</li> <li>3. All data presented by the smart home platform related to the condition of the building.</li> </ol>
	Joshi et al. (2017)	Manage many home devices. Users can watch and access it from anywhere.
Monitoring and safety warnings	Madupu and Karthikeyan (2018)	<ol style="list-style-type: none"> <li>1. Collect data from different sensors such as smoke, passive infrared, vibration, and humidity, check the home environment, and monitor the condition of the house.</li> <li>2. Identify intruders or fire alarms, send information to users when abnormal.</li> </ol>
	Tanwar et al. (2017)	<ol style="list-style-type: none"> <li>1. Use cameras and sensors to monitor the room.</li> <li>2. When the system detects an intruder or any threat, the owner will receive advanced security warning messages such as images and e-mails captured by the system.</li> </ol>

Source: This study.

### Enhance Interactivity

With the progress and development of society, the interaction should not only be reflected in the functions but also focus on the interactive experience of emotions. In the design process of a smart home, the designer should not just solve the basic problems of using the function but also consider the human-computer interaction in the process of using, and regard it as a kind of partner to promote emotional interaction. The cold command language and single operation process can hardly give people a sense of intimacy, while the rich and flexible interactive performance can be more pleasant to the body and mind. Through smart home

control systems and various sensors (Figure 9), residents can break through the limitation of space distance, carry out the multiple smart devices interaction, space and human interaction, psychological and physical interaction, indoor space, and external environment interaction. Carry out real-time information transfer between the space and people, especially the physiological emotions, expression characteristics, body temperature, movement rhythm, heartbeat, and other physiological signals of people are matched with the smart space, to establish the interactive relationship between the user and the space, so as to realize the interactive mode of the smart home and enhance the sense of space experience. For example, intelligent curtains can be controlled to adjust the intensity of light in the room, and intelligent tables and chairs can be controlled to free up space and create a sports field for the user's fitness needs.



Source: Baidu pictures.

Figure 9: Interaction system of a smart home.

### Achieve Technology Integration

Nowadays, the concept of "intelligence" has been rooted in people's hearts, and after enjoying the convenience brought by smart homes, people pay more and more attention to the application of new technology in the home. As an intelligent product, smart home is constantly adapting to the development of society, integrating new technologies into the development of smart homes, and combining with the usage environment of smart homes to make smart homes develop in the direction of more convenience, safety, and comfort. The single and traditional technology can no longer meet the diversified needs of people for smart homes at this stage. Therefore, the realization of a smart home needs the integration and development of several technologies. In the background of big data, artificial intelligence technology (AI), cloud services, cloud computing, Internet of Things technology (IoT), combined with 5G technology, are all important technical contents that need to be introduced and used in smart homes, and are integrated with the development process of smart home, so as to unite more devices and transfer and process information, and realize the effective transformation process of information, which brings new possibilities for the development of smart home, makes the services of smart home more intelligent and humanized. According to user behavior, user habits, environmental scenes, and other kinds of information, it can provide actionable intelligence with self-learning, self-adapting, and self-judging, ask users in advance when running. In the face of complex automated operations and scenes, it can remember and learn, and has the ability to judge the identity of users after system authentication, and provide customized services for users with specific identities, fully forming a user-centered smart home model and realizing a truly smart home life. For example, smart homes can accurately predict users' next behavior and implement it in advance through large-scale data collection and processing. The smart kitchen system will start cooking automatically when the user is off work, and the user can eat when he arrives home, eliminating the process of cooking by himself.

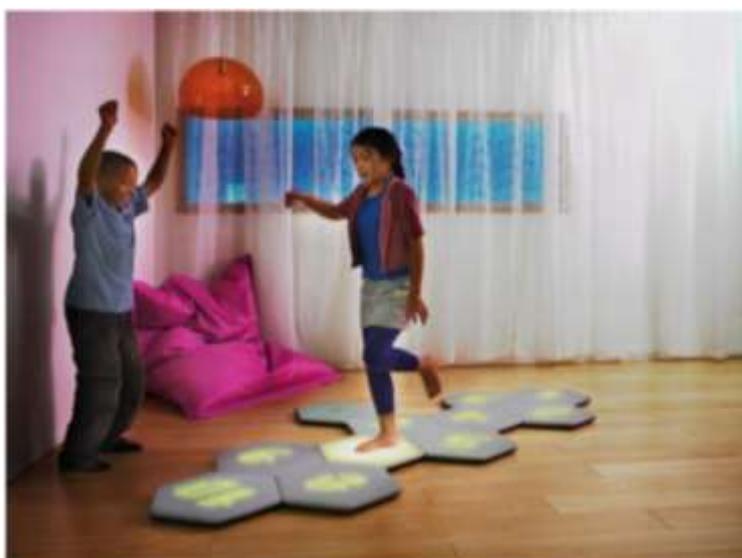
### Practical and Easy to Operate

The principle of practicality is not only the key of design but also the foundation of design. At present, the smart home has the trend of functional integration, and there are more and more functions, but some of them are the wishful thinking of designers, the practicality is not high. Redundant functions increase the difficulty of product operation, which leads to a worse user experience. The complicated use process is easy to make people exclude or even reject, then these functions become a decoration and meaningless. Therefore, practicality and ease of operation are the key factors for users to psychologically accept smart homes. In order to bring users a good user experience, the product must be functional, simple, have clear control, and meet the user's habits.

### Focus on Humanized Design

The concept of humanized design focuses on the diversity of people and the design of smart home products according to their behavioral habits, psychological needs, and physiological structure. At the same time, designers should pay full attention to the needs of users of different ages.

Users of different age groups have different lifestyles and behavioral habits, so the smart home systems are also diverse. For example, children's smart homes should focus on entertainment elements (Figure 10), and smart audio-video systems and VR entertainment systems, etc., can be installed. At the same time, children are in the formative stage of thinking, so the entertainment system should have the correct value guidance, such as smart early education products. Some smart seats should be adjusted according to the growth of children to correct their sitting posture. Young people's smart home is mostly practical and comfortable, and they are accustomed to the automatic cooking and cleaning functions. Smart homes for the elderly are mostly health care, such as wearable smart products that record the blood pressure and heart rate of the elderly from time to time and transmit all kinds of information to various smart home products through Internet of Things technology. In case of abnormalities, the smart home system will take an emergency call service to inform the hospital and children, so that action can be taken the first time. Some elderly people may have visual or hearing impairment or less mobility, so when choosing smart home devices, it is important to consider that these devices should have strong voice recognition capability.



Source: Baidu pictures.

Figure 10: Versa tiles.

### Advocate Energy Saving

At present, smart home products are being updated more and more quickly, and people abandon the original ones in order to pursue the latest technology to meet their daily needs. The life cycle of the products will be shorter and shorter, which makes the cost and power consumption of smart homes relatively large. In order to make more people choose a smart home, broaden the market and achieve sustainable development of smart homes, designers should try to extend the life cycle of smart home products. For example, smart home products can automatically download the latest system to achieve independent optimization of the product, at the same time, reduce energy consumption and power consumption while ensuring its performance. Under the current concept of green development, the energy-saving development of smart home products will become a trend in the future because it not only protects the environment but also helps to reduce costs. Through the design of a smart home, precise control of home appliances and other devices can be realized so as to reduce residential energy consumption. For example, smart windows and smart curtains can greatly help to make rational use of natural light and effectively reduce the frequency and duration of artificial light use. According to the indoor thermal environment and other conditions, the ventilation and temperature systems in smart homes provide users with a suitable temperature and humidity while avoiding the waste of heat and providing a feasible solution for home energy saving.

### Unify Industry Standards

Currently, the most significant problem of a smart home is the lack of uniform standards in the manufacturing and production process. Each smart home manufacturer has its own manufacturing standard, and the relevant smart systems can only be used in its own products. With the gradual popularization of smart homes and the individual needs of users, this problem limits the choice of smart home products for users and hinders the development of the smart home industry. Therefore, it is necessary to establish basic services for cross-platform interconnection, realize the mutual cooperation between products of different platforms, and achieve the unification of smart home application standards. In this way, users will have a wide range when choosing smart home products, rather than being limited to one. Build a perfect interconnection system and truly realize "whole house intelligence."

There are various different smart home products in the market, and due to different protocols among enterprises, the user's terminal control system can only operate specified types of products. At this stage, some enterprises have started to produce smart home series products, taking Xiaomi Smart Home as an example. It has realized information integration and management

among various types of smart home products based on IoT technology. Users can control Xiaomi speakers by voice through the voice interactive control system, and then realize the intelligent control of the rest of the smart home products, and also realize the control of all Xiaomi smart home products through the mobile app, which has initially built a smart home suitable for users to live in. In the future, the development of smart homes is bound to develop towards the standardization of protocols so that only one app can control all kinds of smart homes.

### CONCLUSION

With the rapid development of science and technology, the emergence and application of IoT provides technical support for the development of smart home, extending and expanding the home space, integrating the home as one for leisure, entertainment, relaxation, and life, which can make a pleasant and comfortable experience for the mind and senses. The smart home has become one of the needs of home life. And with the application of IoT technology, there will be more home devices connected to IoT. IoT will become a complex system that is both simple and unimaginable, and the possibilities of those devices integrated with IoT will be unlimited. The diversity of smart home products builds all kinds of different types of the smart home that change the original lifestyle of users. With the arrival of the 5G era and the deep development of smart homes, the combination of IoT technology and the smart home system can better enhance the intelligence level of home life, make the smart home system more perfect, provide a more convenient and effective life experience, and build a harmonious development between people and smart home, which is the future development direction of the smart home.

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## Research on the Impact of Information Quality on Educational WeChat Official Account Users' Continued Use Intention: Based on the ECM-IS Model

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### ABSTRACT

Along with the vigorous development of WeChat official accounts, the number of education WeChat official accounts is increasing day by day. Society's emphasis on education issues extends to the WeChat Official Accounts and other social networking platforms. How to attract users and maintain the willingness of users to continue to use is an important issue for the operators of such public accounts to consider. Information is the main content of the educational WeChat official account, and the evaluation of its quality will directly affect the perception of the educational WeChat official account and then affect the user's willingness to use it. Therefore, based on the perspective of information quality and the ECM-IS model as the research model, this paper subdivides information quality into five dimensions, including comprehensiveness, timeliness, accuracy, relevance, and perceived interestingness, and establishes a theoretical model of the influence of educational WeChat public account information quality on college students' willingness to continue using. This study will have a certain reference value for the education of WeChat operators' practical operation and user stickiness.

*Keywords:* Educational WeChat official account, information quality, ECM-IS mode, the intention of continuous us.

### INTRODUCTION

In August 2012, WeChat launched an official account, which initially revealed its media attributes. Enterprises, public institutions, mass media, social organizations, and individuals have successively registered WeChat official accounts to gain users' attention by pushing information to users so as to expand their influence and obtain economic and cultural benefits (Xu *et al.*, 2015). With the development of the WeChat public platform, educational WeChat public accounts have sprung up like bamboo shoots after a spring rain (Guo & Huang, 2020). People's attention to education is directly reflected in the highly used WeChat public platform (Xu *et al.*, 2015). For the administrators of educational WeChat official accounts, although the registration of educational WeChat official accounts is relatively simple, the main premise of the WeChat official accounts is whether they can attract users to continue to use them.

At present, domestic and foreign researches on the continuous use of online education platform users have formed a relatively complete knowledge system and a relatively mature research process. However, the research period for the education WeChat public platform is relatively short, and there is little overall research, especially empirical research. The research in this field mainly focuses on the development status and communication effect of the educational WeChat public account, as well as the qualitative aspects of university libraries. Research. In addition, few scholars have studied and educated WeChat public platform users' continuous use intentions or behaviors based on the perspective of information quality. However, information is the main content presented by the Educational WeChat Official Account, and the evaluation of its quality will directly affect the perception and evaluation of the Educational WeChat Official Account, which in turn will affect the user's willingness to use it. In view of this, this study has important practical significance for the scientific evaluation of the information quality of the education WeChat public platform, as well as the accurate measurement of the user's satisfaction and the willingness to continue using the educational WeChat public account.

In this paper, the definition of an educational WeChat official account is that it is a public platform mainly for publishing and education-related articles. It disseminates knowledge content of various fields, common knowledge of popular science life, releases educational news and educational trends, etc. (Wang *et al.*, 2019). The target audience is college students. Taking educational WeChat official accounts as the research object, based on the ECM-IS model, which can explain the user's behavior of continuous use of an information system, this paper explores the influence of information quality of such official

accounts on user satisfaction and intention of continuous use. The results of this study can provide a reference for educational WeChat official account to improve user satisfaction and user stickiness and provide a reference for educational WeChat official account operators to improve the release of information. In addition, this study can help to fully understand the influence mechanism of educational WeChat official account information quality on college students' willingness to continue to use, and supplement the relevant research in the field of online education.

## LITERATURE REVIEW

### Research on Educational WeChat Official Accounts

At present, scholars have less research on educational WeChat official accounts, but the scope of research is more extensive. It mainly studies the development status quo and communication effect of educational WeChat official accounts, as well as online education of colleges and universities and public welfare. Yang (2013) explored the current situation and improvement path of educational WeChat official accounts. Guo and Huang (2020) took 39 university libraries in China as research objects and explored how the WeChat platform could improve information literacy education. Wei-Qiong (2017), based on the limitations of current new media in ideological and political education, explores how WeChat public accounts play a role in ideological and political education in colleges and universities. Gao and Wang (2017) believe that mobile terminals provide support for digital map micro-learning, and WeChat public accounts can spread micro-content, promote learners' learning, and have a positive impact on digital map mobile teaching.

### Research on Information Quality

Based on the research background of this paper, the research on information quality in the field of information system management is mainly sorted out. Some scholars mainly studied information quality as an explained variable in the aspects of information content, user perception, and new media websites. For research on information content and user perception. Scholars study information content or information perception individually or combine the two together. Wilson *et al.* (2021) believe that features such as accuracy, reliability, completeness, and timeliness are essential to the information quality of agricultural information systems. Jayasinghe *et al.* (2020) evaluated the readability, usability, and reliability of information quality for COVID-19 searches on public websites such as Yahoo and Google. Schamber *et al.* (1996) believe that clarity, cost, effectiveness, reliability, and relevance are the five main indicators of the user-generated information quality evaluation index system. For new media and knowledge-based website information quality research. Stvilia *et al.* (2009) evaluated the quality of consumer online health information through five dimensions, including completeness, accuracy, authority, usefulness, and accessibility.

Some scholars take information quality as a single independent variable or several dimensions as explanatory variables. When Seddon (1997) revised the success model of the information system, he found that information quality will have a direct positive impact on perceived usefulness and user satisfaction. Jiang *et al.* (2021) discussed the impact of the information quality of social media review platforms on the process of consumer information adoption. Filieri and Mcleay (2014) studied passengers' information adoption behavior based on the fine processing possibility model. They found that central clues such as relevance, accuracy, and timeliness of the information and marginal clues such as commodity ranking will have a significant impact on passengers' comment information adoption behavior.

### Research on Users' Willingness to Continue to Use

When using Internet software, it is very important for users to maintain continuous use behavior after their initial adoption behavior (Bhattacharjee, 2001). Therefore, it is an important topic to study the user's intention of continuous use. According to the research purpose of this paper, this paper mainly analyzes the research on the intention of continuous use of online education users based on a new media platform. Many scholars will integrate the theory of expectation confirmation, technology acceptance, and planned behavior to study the user's intention to continue using. Among them, there are more studies on the intention and behavior of users to continue using MOOC scenarios. For example, Based on the extended expectation confirmation model, Dai *et al.* (2020) introduced new cognitive and affective variables such as curiosity and personal traits to study users' willingness to continue using in the MOOC context. In addition, some scholars have studied users' willingness to continue using online education resources as a whole. For example, based on the ECM model, Sihao *et al.* (2020) studied the factors affecting students' willingness to continue learning on online education live streaming platforms.

### Research Review

To sum up, the related research on the WeChat official account is still in its initial stage of development. Although the scope of research is relatively extensive, there is no in-depth empirical study. In the field of information systems, the research on information quality is relatively mature. Information quality can not only affect user response and behavior as explanatory variables but also become an important index to evaluate information systems as explained variables. Under the background of online education, many scholars explore the influence mechanism of users' willingness to continue to use by combining different perspectives and scenarios based on the traditional theories such as expectation confirmation, technology acceptance, and planned behavior. In the past, the psychological mechanism of WeChat users' behavior has not been thoroughly explored. In addition, information is directly presented and presented to users directly by public numbers. From the perspective of information quality, the official account users can effectively explore the intuitive experience and feelings of official account users. In view of this, based on the characteristics of the WeChat official account, we want to divide the information quality into several dimensions to explore the impact mechanism of users' continuous use intention.

## THEORETICAL BASIS AND RESEARCH HYPOTHESIS

### Theoretical Basis and Research Model Construction

#### Theoretical basis

The ECM-IS model was developed by Bhattacharjee, who applied the expected confirmation model to the field of information systems. Scholars often use this model to study the continuous use behavior of information systems (Halilovic & Cicic, 2013). According to this model, after a user uses an information system for the first time, his perceived usefulness and satisfaction will directly affect his willingness to continue using the information system, and in addition, perceived usefulness and expected confirmation will affect his satisfaction (Bhattacharjee, 2001). Therefore, based on the ECM-IS model, this paper will build a theoretical model of information quality on users' willingness to continue using under the background of educational WeChat official accounts.

#### Research model construction

Official account and official account of WeChat official account for the development of education. The users' needs and feelings of educational WeChat are different. So they will have a different evaluation of the information quality of the WeChat public address. Even if the same user has different satisfaction on the same WeChat public information, the satisfaction will be different. These factors will affect users' willingness to continue to use to a certain extent. When constructing this research model, we should take full account of the user's evaluation of the various dimensions of the information quality of the WeChat official account. Through relevant literature research and based on the ECM-IS model, user satisfaction was introduced as an intermediary variable of educational WeChat users' evaluation of public account information quality, and at the same time as an antecedent variable affecting users' willingness to continue using. Combining the characteristics of the educational WeChat official account, construct a conceptual model of the relationship among the five dimensions of information quality, including comprehensiveness (COM), timeliness (TIM), accuracy (AUC), relevance (REE), and perceived interestingness (PI), user satisfaction (SAT) and user continued intention to use (CI), to explore education The mechanism that affects the information quality of a WeChat official account on its users' willingness to continue using it. The model of this paper is as follows (Figure 1). Comprehensiveness is the information that WeChat's official account is rich, complete, and detailed, which enables users to get extensive learning information. Timeliness is the timely updating of the WeChat official account, enabling users to get real-time and up-to-date learning information. Accuracy means that the education WeChat not only provides correct and reasonable information but also has less irrelevant information, which is conducive to users' search. Relevance means that the information provided by the education WeChat is of great help to users' work and learning. Perceived interest means that the education WeChat provides interesting information. User satisfaction refers to a demand satisfaction state generated by users' comprehensive evaluation of the educational WeChat information quality. The user's continuous use intention refers to the user's subjective desire to use the educational WeChat in the future after using the educational WeChat.

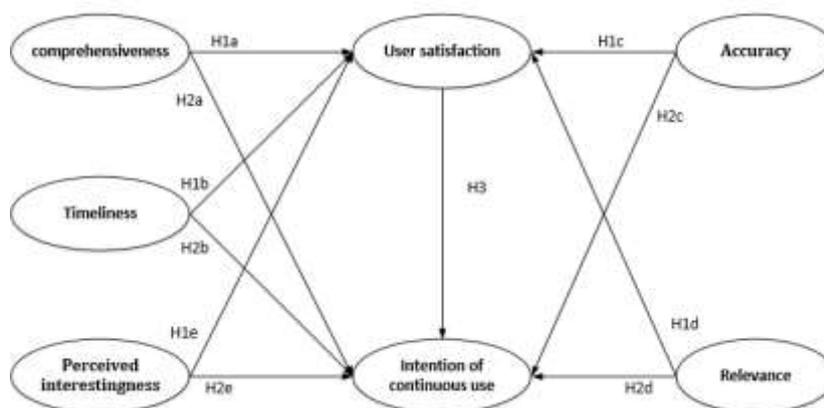


Figure 1: Theoretical model.

### Research Hypothesis

#### Assumptions between information quality and user satisfaction

In the field of information systems, many studies show that information quality has an impact on user satisfaction. In their research on O2O mobile shopping applications, Kim *et al.* (2021) found that information quality has a significant positive impact on consumer satisfaction. When Suliono *et al.* (2016) studied the academic information system of the University of Education Indonesia, he found that the information quality of the academic system significantly affected user satisfaction. The WeChat official account mainly provides users with information about learning. It is precise because of the characteristics of the official account that the user's evaluation of the official account information quality is particularly important. If the information provided by official accounts meets the needs of most users for knowledge information and makes the information obtained by users more accurate on the condition that it is updated in time, then users' satisfaction with such public accounts will be relatively high. As the target audience of this article is college students, interesting and lighthearted articles are more popular with students. Therefore, this paper puts forward the following hypotheses:

H1a: Information comprehensiveness of educational WeChat official accounts positively influences user satisfaction

H1b: Information timeliness of educational WeChat official accounts positively influences user satisfaction

H1c: Information accuracy of educational WeChat official accounts positively influences user satisfaction

H1d: Information relevance of educational WeChat official accounts positively influences user satisfaction

H1e: Information perceived interestingness of educational WeChat official accounts positively influences user satisfaction

***Assumptions between information quality and users' willingness to continue to use***

In the study of users' intention or behavior of continuous use, information quality and other variables simultaneously exert direct or indirect influence on users' intention or behavior of continuous use. Alraimi *et al.* (2015) believe that perceived fun is the core factor affecting users' behavioral intention to continue using. Li and Shang (2020) took information quality as one of the main dimensions of e-government service quality and found that e-government service quality had a significant impact on citizens' willingness to continue using it. When obtaining information from the educational WeChat official account, the user will evaluate the information quality of the official account after the initial experience and decide whether to continue using the WeChat official account according to its evaluation. The richness, correctness, timeliness, and pleasure of the official account information will affect the user's decision to continue using the WeChat official account to some extent. Therefore, this paper puts forward the following hypotheses:

*H2a: Information comprehensiveness of educational WeChat official accounts positively influences users' willingness to continue using*

*H2b: Information timeliness of educational WeChat official accounts positively influences users' willingness to continue using*

*H2c: Information accuracy of educational WeChat official accounts positively influences users' willingness to continue using*

*H2d: Information relevance of educational WeChat official accounts positively influences users' willingness to continue using*

*H2e: Information perceived interestingness of educational WeChat official accounts positively influences users' willingness to continue using*

***Assumptions between user satisfaction and users' willingness to continue using***

In the information system, satisfaction is a positive emotion of recognition to the information system, which can have a positive impact on users' willingness to continue using (Bhattacharjee, 2001). Sihao *et al.* (2020) found that students' satisfaction with online live broadcasting platforms significantly positively affects their willingness to continue learning. Jumaan *et al.* (2020) found that Internet users' satisfaction, perceived usefulness, and cognitive absorption have a significant positive impact on their willingness to continue using. In the educational WeChat public platform, if the information of the educational WeChat official account meets or exceeds users' expectations, then compared with other new media or public accounts that provide educational information, users are willing to spend more time and energy on the education WeChat official account to obtain the beneficial information for themselves. Therefore, this paper puts forward the following hypotheses:

*H3: User satisfaction positively affects users' willingness to continue using*

## EMPIRICAL ANALYSIS

### Questionnaire Design and Data Collection

This paper collects data about the influence of information quality of educational WeChat public accounts on users' willingness to continue using in the form of a unified questionnaire and uses a Questionnaire to sort out the collected data. On the basis of the mature scale of previous studies and the basic characteristics of educational WeChat public account information, the initial questionnaire was designed, the predictive test was conducted in a small range, and the final questionnaire was formed by modification according to the feedback. The questionnaire of this study mainly includes the measurement of variables and the basic information of respondents. In the part of the variable measurement, there are seven variables and 26 variable measure items. These items mainly refer to the studies of scholars such as Balog (2011) and Bhattacharjee (2001). The part of basic information includes the user's gender, educational background, the channel of paying attention to WeChat, the history and frequency of using WeChat. The Likert 5-level scale was used in the questionnaire. According to the degree of agreement with the questions, the questionnaire was divided into strongly disagree, relatively disagree, generally agree, relatively agree, and strongly agree, with 1-5 points, respectively. This paper takes college students who have used educational WeChat public accounts as the objects of investigation and collects questionnaires by issuing paper questionnaires and online questionnaires in WeChat circle of friends and QQ group. A total of 364 questionnaires were collected, and 322 valid ones were obtained after eliminating invalid ones, such as incomplete ones and large deviations.

According to the descriptive analysis of the samples, girls accounted for 73.29%, while boys accounted for 26.71%. ; In terms of educational background, 83.23% of the students received bachelor's degrees, and 16.77% of the students received master's degree or doctor's degree. Among the respondents, 54.35% of users have been following such WeChat public accounts for more than six months. Users use educational WeChat official accounts 1-3 times and 4-6 times each month. The respondents mainly paid attention to educational WeChat public accounts through three channels: friend recommendation, active search, and article attention.

## Data Analysis and Results

### Reliability test

Reliability reflects the stability and reliability of the scale. The higher the reliability, the higher the reliability of the scale. In this study, the questionnaire data were processed by SPSSAU software, and the Cronbach's  $\alpha$  coefficient of each variable was used to verify the reliability of the scale. According to the standards of Hair *et al.* (1998), Cronbach's  $\alpha$  coefficient above 0.70 was the acceptable minimum reliability value. As can be seen from Table 1, the Cronbach's  $\alpha$  coefficient of the total table was 0.937, and the Cronbach's  $\alpha$  coefficient of all latent variables was greater than 0.7, indicating that the scale in this study had high reliability.

Table 1: Reliability and convergence validity of survey data.

Latent variable	Number of questions	Cronbachs alpha coefficient	AVE value	CR value
COM	4	0.776	0.470	0.779
TIM	3	0.755	0.506	0.753
AUC	4	0.705	0.370	0.700
REE	3	0.754	0.499	0.749
PI	5	0.832	0.501	0.833
SAT	4	0.820	0.536	0.821
CI	3	0.786	0.552	0.787

### Validity test

Validity reflects the validity degree of the variable measurement items. In this study, convergence validity and discriminant validity were used to test the validity of the scale. In terms of convergence validity test and analysis, the acceptable range of average variance extraction value, namely the AVE value, is 0.36-0.5. Under ideal conditions, the AVE value needs to be greater than 0.5 (Hair *et al.*, 1998), and the general standard of the AVE value is greater than 0.4. As can be seen from Table 1, the AVE value of comprehensiveness and correlation is slightly lower than the ideal level of 0.5 but meets the general standard. The accuracy of the AVE value is within the acceptable range, slightly below the general standard; AVE values of timeliness, perceived interestingness, user satisfaction, and willingness to continue using are all greater than the ideal level of 0.5. According to the standards of Hair *et al.* (1998), the lowest level of CR value is 0.7. The combined reliability of all latent variables in this paper, i.e., CR value, is greater than 0.7. In general, the questionnaire in this study has good convergence validity.

In terms of discriminant validity test and analysis, the arithmetic square root of AVE value of each latent variable is greater than the correlation coefficient with other variables (as shown in Table 2), indicating that the discriminant validity of the scale in this study is good (Fornell & Larcker, 1981).

Table 2: Discriminative validity analysis table.

Measured variables	COM	TIM	AUC	REE	PI	SAT	CI
COM	0.685						
TIM	0.551	0.711					
AUC	0.535	0.480	0.609				
REE	0.537	0.612	0.588	0.706			
PI	0.499	0.496	0.465	0.547	0.708		
SAT	0.576	0.541	0.591	0.617	0.673	0.732	
CI	0.541	0.464	0.529	0.533	0.621	0.716	0.743

### Model fitting and hypothesis testing

SPSSAU is used for model fitting and empirical analysis. As can be seen from Table 3, all the fitting indexes have reached the standard of the reference value, indicating that the data collected have a good degree of fitting with the model as a whole.

The hypotheses of the model were tested, and the results are shown in Figure 2. There were 11 hypotheses in total, most of which were verified, and only four hypotheses failed to pass the verification. Timeliness has no significant positive effect on user satisfaction, nor does it have a significant effect on the willingness to continue using. That is to say, H1b and H2b are not valid. Accuracy and correlation have no significant positive effect on the intention to continue using. That is, hypotheses H2c and H2d are not valid.

Table 3: Model goodness of fit test.

Fitting index	reference	Measured value
$\chi^2/df$	<3	1.711
GFI	>0.8	0.896
AGFI	>0.8	0.869
RMSEA	<0.08	0.047
IFI	>0.9	0.946
NFI	>0.8	0.880
CFI	>0.9	0.946
NNFI	>0.9	0.937

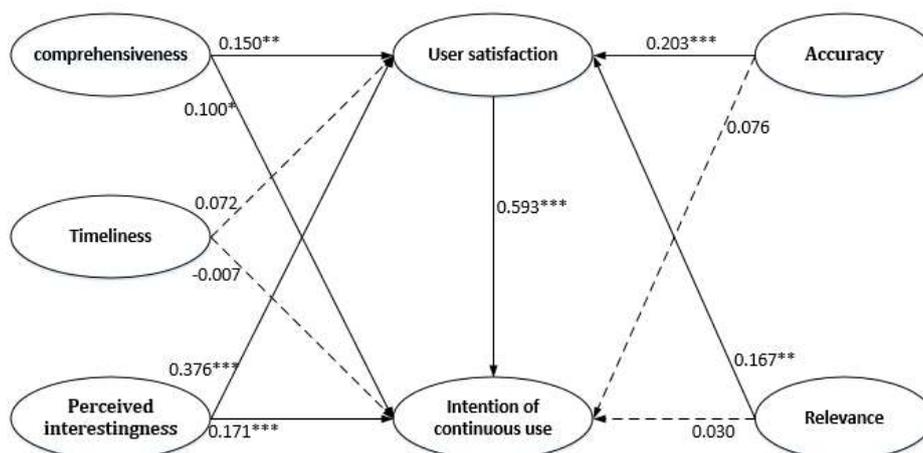


Figure 2: Model hypothesis test results.

## RESULTS AND DISCUSSION

### Conclusion

Based on the ECM-IS model and according to the characteristics of educational WeChat official accounts, this paper introduces five variables, including comprehensibility, timeliness, accuracy, relevance, and perceived interestingness, to build a model of the influence of educational WeChat official accounts information quality on the intention to continue using, and adopts an empirical method to analyze. The main conclusions of this study are as follows:

The comprehensiveness, accuracy, relevance, and perceived interestingness of educational WeChat official account information have a significant positive impact on user satisfaction, which in turn has a significant positive impact on continued use intention. The conclusion verifies that the user's satisfaction with the quality of the education WeChat official account has an impact on the user's willingness to continue using it. This is consistent with the results of previous studies. It can be seen that user satisfaction is largely affected by the comprehensiveness, accuracy, relevance, and perceived interest of WeChat official account information. This is in line with the actual situation of users using this kind of WeChat official accounts. College students use educational WeChat official accounts to obtain useful information and knowledge. The comprehensive and accurate information is very important, and these factors largely affect users' satisfaction with this kind of WeChat official accounts. In addition, college students are more sensitive to interesting words and pictures, and their perception of the fun of WeChat official accounts makes them favor the official accounts. Therefore, education WeChat official accounts should pay attention to the accuracy and perceived interest of the information released, and at the same time, the construction of comprehensiveness and relevance of information should not be ignored.

The timeliness of educational WeChat official account information has no significant impact on user satisfaction and intention to continue using. Contrary to the hypothesis, timeliness has a slight negative impact on intention to continue using, but the impact range is small and can be almost ignored. When college students get information from the educational WeChat official account, they may not be sensitive to the timely update of information, or they may not know the latest learning content, which makes them unable to evaluate the information quality from the aspect of the timeliness of the information and generate a sense of satisfaction and the willingness to continue to use it. In addition, user satisfaction does not have a significant mediating effect in the impact of timeliness on users' continuous use intention, which is in line with the assumption that timeliness does not have a significant impact on user satisfaction.

The comprehensiveness and perceived interestingness of educational WeChat official account information has a direct and significant positive impact on users' willingness to continue using. However, the accuracy and relevance of official account information have no significant positive impact on users' willingness to continue using. The results show that college students can have a direct perception of the comprehensiveness and interestingness of the official account information when they first

use the educational WeChat official account. With the increase of the number of users and the increase of familiarity, they have a more comprehensive understanding of the comprehensiveness of the official account information and the degree of entertainment interest. The accuracy and relevance of information quality require users to experience the first use to verify the truthfulness, search convenience, and usefulness of the information. Accuracy and relevance affect the user's intention to continue using behavior through the satisfaction and satisfaction generated by the user's investigation of the official account after use.

### Management Enlightenment

For the official account of WeChat, the conclusion of this paper will help operators to relocate and reflect on the future development path of the WeChat official account so as to meet the actual needs of more college students, and even the needs of other users, in order to enhance customer satisfaction and enhance user stickiness. From the research conclusion: first, operators should pay attention to the comprehensiveness of the information presented. Operators can continuously improve the function of the WeChat official account, enrich the knowledge and information content of the official account, and provide information to users in different needs to get users' satisfaction. At the same time, the recommendation of fragment information should be reduced to avoid information deviation. Second, creators should not pursue the update speed too much but pay more attention to other aspects of content. Although the push article will automatically show the time of information update, the satisfaction of college students with information will not be affected by the timeliness of information, so operators should pay attention to the construction of other aspects of information quality. Third, operators need to use authoritative information sources. Authoritative information sources can ensure the accuracy of the information and help users improve learning efficiency. Fourth, the operator needs to provide relevant information in line with the user's learning characteristics. The improvement feedback can be obtained by means of network surveys and online comments so as to reduce the recommendation of irrelevant information and reduce the negative emotions such as fatigue and pressure caused by information overload. Fifth, operators need to improve users' interest in reading. Users' psychological perception is the key factor affecting their behavioral intention. Interesting pictures and words can reduce reading fatigue, improve users' interest, and be more in line with the psychological characteristics of college students.

### Research Limitations

Under the official account of WeChat, this paper explores the influence of public information quality characteristics on user behavior, enriching the academic research of the WeChat official account. However, there are still some deficiencies in the research: first, there are many factors affecting user satisfaction and its willingness to continue to use, and this research model can not be listed one by one for discussion. Other influencing factors can be considered in future research to supplement and expand this study. Secondly, this study only focuses on the continuous use intention of educational WeChat to college students. Future research can explore various influencing factors and formation mechanisms of users' initial use and even combine the two to systematically analyze the overall mechanism of educational WeChat users' use intention. Thirdly, this study does not discuss other possible intermediary processes, which can be analyzed from the aspects of user characteristics and social impact in the future. Finally, this article does not differentiate the educational WeChat official account. Different types of official accounts have different characteristics. Future research can investigate and research official educational accounts for a certain feature to get more targeted results.

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## Research on the Influencing Factors of Users' Willingness to Pay for Knowledge in the Context of Virtual Brand Community

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### ABSTRACT

With the rapid development of the mobile Internet, the knowledge payment market has developed rapidly. Due to the short development time, community operators lack an in-depth understanding of user behavior. There are still many problems to solve, like knowledge convergence and poor service. Based on this background, this research combines the Technology Acceptance Model with the D&M information systems success model and incorporates the perceived value theory, Community identity theory, and so on, to construct a research model of user's intention to participate in knowledge payment in the context of virtual brand community. The study found that user community experience factors can significantly affect personal perception, while users' personal perception, such as perceived usefulness and perceived playfulness, can affect users' recognition of the community and thus affect their willingness to pay. Finally, this study puts forward suggestions for the operation managers of the knowledge-paid community.

*Keywords:* Virtual brand community, knowledge payment, willingness to pay, community identity theory.

### INTRODUCTION

The rapid development of mobile Internet technology not only brings us great convenience but also intensifies the degree of information explosion. The cost of obtaining high-quality information is gradually increasing, so people have an increasingly strong demand for high-quality information resources. The rapid development of mobile payment has made the development of online and offline payment systems more complete. Knowledge sharers who are willing to contribute to the knowledge payment community to obtain realization needs have gained more convenience, and people are willing to pay for knowledge in order to obtain the information. In this context, the number of users participating in payment for knowledge in China continues to increase, and it is still in a stage of rapid and stable development. The outbreak of COVID-19 promoted the further development of the pan-knowledge payment industry. According to existing surveys, nearly 90% of users purchased knowledge payment products in 2020, and 63.1% of users purchased knowledge payment products during the epidemic period, which are mainly related to workplace skills, personal growth, and K12 (Ardito *et al.*, 2020).

The rapid development of the knowledge payment industry attracts online communities, so they also joined Inspur to start a community payment model. The virtual brand community can break the constraints of time and space, and provide community members with relevant information more efficiently and conveniently, which is to a large extent convenient for Participation in activities of community members. However, due to the immature operating model of the virtual community development and the lack of relevant information screening and evaluation mechanisms, the development of the knowledge payment model is also affected by it. Most knowledge payment communities have begun to report that the loss of members is serious, and the participation rate has decreased. In addition, community knowledge payment pricing is uneven, knowledge generalization is also serious, coupled with the lack of after-sales service, the loyalty of many users is declining, and the enthusiasm for learning is gradually reduced, and the willingness to pay decreases and gradually disappears.

The existing research on knowledge payment is relatively single (Ajzen, 1991). When studying user payment behavior, scholars mostly use the same theoretical model, and the research is based on the theory of planned behavior to explore and supplement, and there are few discussions from the dimension of the virtual brand community (Muniz & O'Guinn, 2001). The virtual brand community has become the main gathering place for user participation and communication. At present, the knowledge payment community lacks an in-depth understanding of user psychology and behavior. The insight into the user knowledge payment behavior and its influencing factors is helpful to improve the quality of knowledge service and build the core competitiveness of the online payment question answering community. The willingness and behavior of users to pay is the key to the success of the knowledge payment model, so it is necessary to study the user behavior of the knowledge payment community to improve the willingness of users to pay. This study provides a new perspective for the study of knowledge payment from this field.

## LITERATURE REVIEWS AND RESEARCH HYPOTHESIS

### Virtual Brand Community

Muniz and O'guinn (2001) first proposed the brand community. Due to the immature development, there is no unified view in the existing research and industry. Rheingold (1993) first named it as Virtual Community. In his opinion, a virtual community is a gathering of people to communicate and discuss. With the development of technology, brand communication began to have revolutionary changes, and major brands have established their own online network communication communities. Brands and communities have gradually been linked for research. Virtual brand communities have also gradually developed at this time. Community members can carry out information exchange and emotional connection for brand products in the virtual brand community so as to enhance the loyalty of the platform. At the same time, the brand is well-publicized in an invisible way, and the platform gives full play to the role of jointly creating value. In his research, Kozinets (2001) believed that community members mainly used the convenience of the Internet to communicate information in the community so as to form their own cognition of the community's emotional attitude. Amine and Sitz (2004) believe that virtual brand communities serve for members from different regions to gather together and share the same feelings through the same brand preferences. It is precisely because the content services provided in the community satisfy the personalized needs of consumers, and the community information knowledge is too extensive to focus on the needs of individual brand preferences. Therefore, groups interested in specific brands have formed such a place for communication through online media.

### Study on Knowledge Payment

Paying for knowledge simply means paying for the information you need. It is a mode of paying and knowledge spreading that relies on online communities to serve the public. People can freely share knowledge, consult and exchange courses in the community. Knowledge service is different from other paid goods, and its seriousness and originality put forward strict requirements on knowledge sharers. The knowledge shared should be not only professional and rigorous, scientific and can withstand scrutiny, but also be original and valuable to share. Existing research on knowledge payment mainly focuses on user participation behavior, Q&A community content quality, user satisfaction, and so on.

Based on user participation behavior, Kuo and Feng (2013) found from the perspective of social interaction that the interaction between users based on a brand community can increase their perceived benefits, thus further influencing consumer behavior. Ifeld and Winer (2002) believe that consumers will increase their browsing and purchasing behavior when they feel that the web page design is user-friendly. Based on Q&A community content quality, Dou (2004) constructed a theoretical model based on perceived risk for research, and the research showed that the value of knowledge use within the community has a significant impact on users' knowledge payment behavior. Hsiao (2011) used the perceived value theory to analyze the specific value meaning perceived by users in the community and within the community and concluded that the greater the perceived value of users, the higher the dependence on the platform and the higher the cost of leaving. Based on user satisfaction, Chang *et al.* (2014) investigated the antecedents and results of perceived value, found that perceived value positively influenced user satisfaction and directly influenced the willingness of community members to continue using. Hong *et al.* (2017) revealed that practical value and hedonic value are the key factors for consumers to choose to use smartwatches continuously.

Through the collation and analysis of relevant literature, it can be seen that the rapid development of knowledge payment in recent years has also encountered development bottlenecks. The quality of related community platforms needs to be improved. The lack of a full understanding of user psychological behavior has led to a decline in user participation, and the knowledge structure and influence of community providers are lacking. The quality of related community platforms needs to be improved. The lack of a full understanding of user psychological behavior has led to a decline in user participation, and the knowledge structure and influence of community providers are lacking. It is difficult to meet the expectation of users to confirm and identify trust. At present, the existing researches mostly focus on the willingness to pay from the perspective of user behavior or satisfaction, while there is few research on the user experience of the virtual brand community, and no consistent conclusions have been drawn.

### Quality of the Community

D&M Information system success model was proposed by Delone & Mclean (1992). This model mainly explains the relationship among the basic elements of an information system, including information quality, system quality, system use, user satisfaction, personal influence, and organizational influence, and how to affect the success of an information system. However, it was questioned by some scholars in the later practice and application. Seddon (1997) believed that willingness to use should be replaced by effectiveness and introduced systematic importance. Meanwhile, the two-way influence between willingness to use and satisfaction was replaced by a one-way influence of effectiveness on satisfaction. Pitt *et al.* (1995) believed that the information system success model did not consider the quality of service of the information system enough, and service quality should be summarized as one of the evaluation criteria for the success of the information system. With the deepening of research in the field of information systems, DeLone and McLean (2003) modified and improved the original model, put forward the improved DM model, adding service quality to the evaluation index of the information system, giving full consideration to users' recognition and feelings of service, making the success model of information system more comprehensive. Based on the DM model, system quality, information quality, and service quality are regarded as second-order variables of community quality to evaluate the quality of the virtual brand community.

Existing studies have confirmed that the quality of the information system will directly affect users' perceived usefulness, expected confirmation, and willingness to continue using. Wangpipatwong *et al.* (2005) believe that users' adoption of government portal websites is mainly influenced by the quality of website information and system. Therefore, this study believes that whether the operation of the internal system in the community is stable, the cost and quality of information acquisition, and whether the community service is convenient and efficient will also have a direct impact on users' personal perception. Therefore, the following hypotheses are proposed:

H1: The quality of virtual brand knowledge paid community has a positive impact on perceived usefulness.

H2: The quality of virtual brand knowledge paid community has a positive impact on perceived ease of use.

H3: The quality of virtual brand knowledge paid community has a positive impact on perceived playfulness.

### **Perceived Value**

Zeithaml (1988) believes that customer perceived value refers to the difference comparison between the efforts made by the customer and the gain when using the product and thinks that the gain is more than the cost paid is valuable. This theory is the difference between the perceived value and cost of community members after purchasing the knowledge payment service, and this feeling indirectly affects the overall evaluation and willingness of the knowledge payment service. Hsiao (2011) explored users' willingness to pay by using the perceived value theory and found that users' perceived value significantly affected users' willingness to pay. Therefore, the hypothesis is proposed:

H4: Perceived value has a positive impact on perceived usefulness.

H5: Perceived value has a positive impact on perceived ease of use.

### **Expectation Confirmation and Personal Perception**

Expectation confirmation theory is developed on the basis of expectation unconfirmation theory. Oliver (1980) believes that the difference between consumers' expected expectation before product purchase and actual performance after product purchase is expectation unconfirmation, and satisfaction will also be generated in this process, which will further influence consumers' purchase intention and behavior. The theory of expectation uncertainty gradually developed and matured. Churchill and Surprenant (1982) added perceptual performance into the theory of expectation uncertainty, enriching and improving the theory. In this study, expectation confirmation variables were used to measure the pre and post prediction and actual matching degree of perceived effects of consumers using paid services, and the following hypotheses were proposed:

H6: Expectation confirmation has a positive impact on perceived ease of use.

H7: Expectation confirmation has a positive impact on perceived playfulness.

### **Personal Perception and Social Identity**

According to the TAM model, consumers' perceptions of usefulness in the process of using information systems, which will continue to use the system was influenced by the attitudes. If consumers believe that the virtual brand community can make people physically and mentally happy, increase their knowledge, and improve efficiency, they believe that If the platform is useful, then it is likely to have a positive attitude and willingness to use the virtual brand community, thereby increasing the sense of identity with the community. Similarly, when consumers feel that the operating system is easy to use, they will usually think that the system is useful and have a positive attitude towards the system. When consumers perceive the virtual brand community as easy to use and feel that the system is stable and convenient to operate, they may have more positive attitudes and recognition towards the community.

Webster and Martocchio (1992) believe that entertainment can also represent a person's personal characteristics to some extent, and people with entertainment tend to show higher enthusiasm and participation in work and life. Davis (1989) introduced the Perceived usefulness as the internal psychological motivation of users into the TAM model to study the excitement of users in the process of experience. In this study, perceived playfulness refers to the subjective happiness that consumers feel in the process of knowledge payment in the virtual brand community. Perceived playfulness pays more attention to the internal psychological state of users, which is an internal manifestation. When users feel that the experience of a certain technology is interesting when they operate it, their inner satisfaction with the technology will be improved, and their subsequent use of the technology will also have a positive impact (Nysveen *et al.*, 2005).

Based on this, the following hypotheses are proposed:

H8: Perceived usefulness has a positive impact on community identity.

H9: Perceived ease of use has a positive impact on community identity.

H10: Perceived playfulness has a positive impact on community identity.

### **Community Identity and Willingness to Pay**

This theory is developed from social identity theory. When users participate in virtual brand community activities, they regard themselves as a member of the community, and the familiarity and trust continuously developed in the process are the development process of community identity. At the same time, the key link between the members of the brand community is the

support and love for the brand in the community, and the relationship between everyone in the community develops continuously due to the same cognition. Community identity is mainly developed from three dimensions: cognition, evaluation, and emotion. Community members will actively participate in community publicity and promotion activities when their recognition of the community reaches a certain degree. Cognitive identification refers to the confirmation of one's membership in the community, evaluation identification refers to the positive and negative evaluation value of members in the community, and emotional identification refers to one's feelings invested in the community. Social identity in the virtual brand community mainly refers to consumers' trust and agreement on the operation norms, atmosphere, and goals of the community. Teng (2017) study shows that identity significantly influences online game users' community participation behaviors. Shapiro *et al.* (2019) explored the factors influencing users' willingness to pay for watching competitive sports and found that the higher the level of approval, the higher the willingness to pay. In the virtual brand community, the user of the cognition of themselves and their communities agreed to produce the corresponding identity, which is to think their own preferences and demand match the community to provide payment information, and community sense of belonging and identity, under its push to produce active pay intention and behavior. Based on this, the following hypotheses are proposed:

H11: Community identity has a positive impact on willingness to pay.

Therefore, the theoretical model of this research is shown in Figure 1.

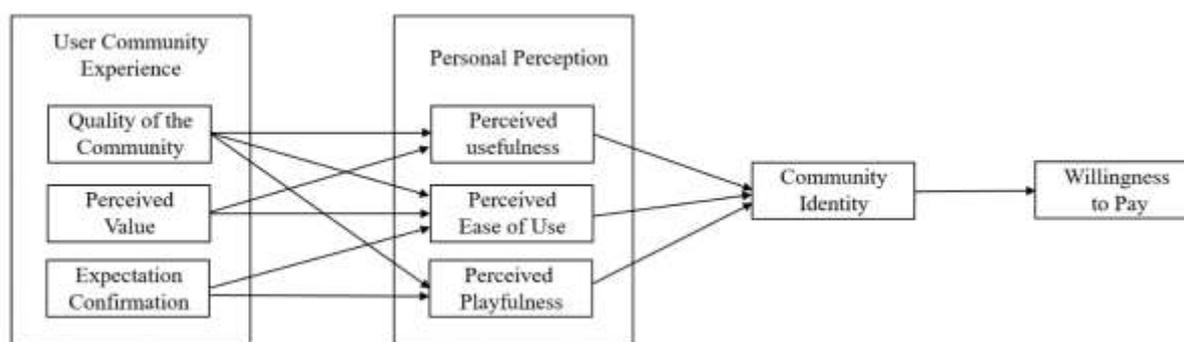


Figure 1: Research model

## RESEARCH DESIGN AND EMPIRICAL ANALYSIS

### Scale Design

This paper adopts the questionnaire survey method. In order to ensure the authority of each variable definition, through the previous literature review and the specific actual situation of paying for virtual brand community knowledge, this research has made a corresponding variable definition for each variable. In this study, classical scales were referred to, and a predictive test was conducted. According to the feedback of the predictive test, the questionnaire was modified to form the final questionnaire. The research model in this paper has a total of 8 variables, and a total of 37 items are set in the questionnaire and measured in the form of a Likert 7-level scale.

### Data Collection

The questionnaire object of this study is divided into two categories: one is the consumers who have paid for the knowledge of virtual brand community but have not participated in the purchase behavior, and the other is the consumers who are using the paid service of virtual brand community knowledge. The questionnaire is divided into two parts. The first part is the filling in of basic personal information, and the second part is the influencing factors of consumers' knowledge payment in the context of virtual brand community. To ensure the rationality and validity of the questionnaire, the questionnaire is distributed in two periods: (1) Pre-survey stage. A total of 103 questionnaires were distributed, and the data were used to modify the questionnaire. The collected data are analyzed by SPSS24.0 for the reliability and validity of the questionnaire. Finally, according to the corresponding feedback, the content and structure of the questionnaire are enriched and improved to ensure the scientificity and validity of the final questionnaire. (2) Formal investigation. During the formal survey period, 406 questionnaires were distributed for a total of two months. A total of 392 valid questionnaires were obtained after eliminating the questionnaires with inconsistent answers and less than one minute of answer time.

SPSS24.0 was used for descriptive analysis, and the results are shown in Table 1:

Table 1: Descriptive Statistical Analysis

Basic Features	Classification	Number of Samples	Proportion(%)
Gender	male	189	48.21%
	female	203	51.79%
Age	Under the age of 18	24	6.12%
	18-25 years old	256	65.31%
	26-30 years old	52	13.27%

	31-35 years old	18	4.6%
	36-40 years old	32	8.16%
	41-50 years old	8	2.04%
	50 years of age and above	2	0.51%
Education	High school and below	32	8.16%
	Specialized subject	67	17.1%
	Undergraduate course	246	62.76%
	Master degree or above	47	11.99%
Monthly income	Below 1000 yuan	23	5.87%
	1000-1500 yuan	178	45.41%
	1500-2000 yuan	67	17.1%
	2000-5000 yuan	85	21.68%
	5000-8000 yuan	32	8.16%
	8000-10000 yuan	5	1.28%
	More than 10000 yuan	2	0.51%
The monthly payment for knowledge	0 yuan	243	61.99%
	Within 50 yuan	100	25.51%
	50-100 yuan	36	9.18%
	100-500 yuan	12	3.06%
	More than 500 yuan	1	0.26%
Knowledge of paid platform usage	get	145	36.99%
	Wu Xiaobo channel	24	6.12%
	Himalayan FM	56	14.29%
	Climb to read	78	19.9%
	University of Zhihu	168	42.86%
	Litchi micro class	38	9.7%
	Open the krypton	13	3.32%
	Little red circle RedRing	26	6.63%
	Netease Cloud Classroom	89	22.7%
	Weibo q&a	65	16.58%
	Other platforms	28	7.14%
	Never used it	45	11.48%
Knowledge payment behavior	Yes	247	63.01%
	No	145	36.99%

### Reliability and Validity Test

This article uses Cronbach's  $\alpha$  coefficient to evaluate the reliability of the collected samples. The results of the reliability analysis of data by SPSS24.0 are shown in Table 2.

Table 2: Reliability Test

Variable	Correlation coefficient between sub-term and total term	The $\alpha$ coefficient after deleting the item	Cronbach's $\alpha$
System quality			0.869
SQ1	0.737	0.832	
SQ2	0.797	0.784	
SQ3	0.73	0.834	
Information quality			0.786
IQ1	0.747	0.577	
IQ2	0.503	0.831	
IQ3	0.649	0.69	
Quality of service			0.832
SEQ1	0.691	0.779	
SEQ2	0.699	0.765	
SEQ3	0.7	0.761	
Perceived value			0.951
VAL1	0.827	0.954	
VAL2	0.896	0.932	
VAL3	0.911	0.929	

VAL4	0.913	0.926	
Expectation confirmation			0.938
C1	0.886	0.901	
C2	0.844	0.934	
C3	0.894	0.892	
Perceived usefulness			0.888
PU1	0.568	0.925	
PU2	0.786	0.845	
PU3	0.867	0.81	
PU4	0.819	0.832	
Perceived ease of use			0.895
EA1	0.75	0.89	
EA2	0.827	0.825	
EA3	0.808	0.838	
Perceived playfulness			0.921
ENJ1	0.86	0.869	
ENJ2	0.779	0.941	
ENJ3	0.888	0.849	
Community identity			0.941
CSI1	0.825	0.93	
CSI2	0.849	0.929	
CSI3	0.846	0.929	
ESI1	0.778	0.934	
ESI2	0.707	0.939	
ASI1	0.85	0.929	
ASI2	0.653	0.942	

As can be seen from the above table, Cronbach's  $\alpha$  coefficient values of most variables are greater than 0.8, indicating that the reliability of this questionnaire basically meets the requirements.

The validity is measured by comparing the running-in degree between the measured data results and the actual things. The closer the measured results are to the actual results, the higher the reliability is. In this study, the principal component analysis method in confirmatory factor analysis was used to extract factors. In the Kaiser-Meyer-Olkin test and Bartlett sphericity test, the KMO value should be greater than 0.6. The results are shown in Table 3.

Table 3: Validity Test

Variable	Kaiser - Meyer - Olkin inspection	Bartlett's test		
		Approximate chi-square	Degree of freedom	Significant
System quality	0.741	150.822	3	0.000
Information quality	0.713	145.914	3	0.000
Quality of service	0.705	120.467	3	0.000
Perceived value	0.826	374.292	6	0.000
Expectation confirmation	0.763	241.733	3	0.000
Perceived usefulness	0.843	310.077	6	0.000
Perceived ease of use	0.709	127.111	3	0.000
Perceived playfulness	0.745	251.503	3	0.000
Community identity	0.925	798.989	28	0.000
Payment will	0.757	201.084	3	0.000

As can be seen from the table, the KMO values of this study are all greater than 0.6, and most of them are between 0.7-0.9. Bartlett's sphericity test is significant, so factor analysis will be continued.

Table 4: Total Variance Interpretation

Composition	Initial eigenvalue			Extract the sum of squares and load			Rotate squares and load		
	Total	variance %	Accumulation %	Total	variance %	Accumulation %	Total	variance %	Accumulation %
1	21.415	57.878	57.878	21.415	57.878	57.878	9.128	24.669	24.669
2	3.099	8.376	66.255	3.099	8.376	66.255	7.503	20.279	44.948
3	1.721	4.651	70.905	1.721	4.651	70.905	5.917	15.993	60.941

4	1.231	3.328	74.233	1.231	3.328	74.233	4.070	11.001	71.942
5	1.006	2.718	76.951	1.006	2.718	76.951	1.853	5.009	76.951
6	.937	2.533	79.484						
7	.713	1.926	81.410						
8	.702	1.896	83.306						
9	.571	1.544	84.850						
10	.492	1.330	86.181						
11	.475	1.284	87.464						
12	.403	1.090	88.554						
13	.385	1.042	89.596						
14	.341	.921	90.517						
15	.315	.850	91.367						
16	.289	.781	92.148						
17	.286	.772	92.920						
18	.278	.751	93.671						
19	.240	.648	94.319						
20	.209	.565	94.884						
21	.193	.521	95.405						
22	.184	.497	95.903						
23	.173	.467	96.370						
24	.163	.439	96.809						
25	.142	.384	97.193						
26	.136	.369	97.562						
27	.130	.351	97.912						
28	.118	.318	98.231						
29	.104	.282	98.513						
30	.097	.263	98.776						
31	.088	.238	99.014						
32	.083	.224	99.238						
33	.074	.201	99.439						
34	.061	.164	99.603						
35	.054	.146	99.749						
36	.050	.135	99.884						
37	.043	.116	100.000						

Five factors were extracted from total variance interpretation, and the factor interpretation level was good, with the cumulative variance contribution rate reaching 76.951%.

### Model Fit Test

In this study, AMOS20.0 was used to calculate the fit index of the structural model. Table 5 shows that the fit indexes of the structural model all meet the requirements of the recommended values, which indicates that the overall fit of the structural model is good and can be used to verify the research hypothesis.

Table 5: Model Fit Index

Indicators	Evaluation standard		Model values
	Acceptable	Good	
(Chi-Square/d.f)	1-3 Perfect	3-5 Good	5-8 Acceptable
Absolute fit index	GFI	[0/7,0.9)	>0.9
	AGFI	[0/7,0.9)	>0.9
	RMSEA	<0.08	<0.05
Relative fit index	NFI	[0/7,0.9)	>0.9
	TLI	[0/7,0.9)	>0.9
	CFI	[0/7,0.9)	>0.9
Information index	AIC	the smaller, the better	
	CAIC	the smaller, the better	

### Hypothesis Testing

AMOS 20.0 was used in this study to conduct path analysis on the structural model by maximum likelihood estimation.  $P < 0.05$  is taken as the standard for hypothesis testing. The final verification results of the judgment on the hypothesis based on the model fitting results are shown in Table 6.

Table 6: Model Test Results

hypothesis	relationship	Estimate	S.E.	C.R.	P-value	Standardized Path coefficient	Test result
H1	Perceived usefulness <--- Quality of the community	.3215	.0749	4.2896	***	.3809	Support
H2	Perceived ease of use <--- Quality of the community	.2848	.1060	2.6881	.0072	.2599	Support
H3	Perceived playfulness <--- Quality of the community	.0701	.1324	.5290	.5968	.0568	Not Support
H4	Perceived usefulness <--- Perceived value	.4750	.0759	6.2616	***	.5628	Support
H5	Perceived ease of use <--- Perceived value	.5434	.1264	4.3001	***	.4958	Support
H6	Perceived ease of use <--- Expectation confirmation	.1501	.1058	1.4196	.1557	.1370	Not Support
H7	Perceived playfulness <--- Expectation confirmation	.7384	.1299	5.6859	***	.5988	Support
H8	Community identity <--- Perceived usefulness	.3853	.1011	3.8132	***	.2978	Support
H9	Community identity <--- Perceived ease of use	.2388	.0805	2.9654	.0030	.2397	Support
H10	Community identity <--- Perceived playfulness	.4404	.0517	8.5236	***	.4972	Support
H11	Payment will <--- Community identity	.7977	.0639	12.4792	***	.8077	Support

Note: \*\* means significant at 0.001 level

According to the hypothesis test results in Table 6, it can be seen that the P values of H3 and H6 are greater than 0.5, and the hypothesis is not valid. The P values of other hypotheses are all less than 0.05, indicating that the remaining nine hypotheses are valid.

## CONCLUSION AND FUTURE WORK

### Results and Discussion

In view of the phenomenon that users' willingness to pay in virtual brand communities is declining, this study draws corresponding conclusions by issuing questionnaires and analyzing data.

#### *The relationship between user community experience and personal perception*

In this study, community quality, expectation confirmation, and perceived value were taken as community experience factors, while perceived usefulness, perceived ease of use, and perceived playfulness were taken as personal perception factors. According to the research conclusions, community quality significantly affects perceived usefulness and perceived ease of use but has no significant impact on perceived playfulness. Considering the actual situation, when users pay for knowledge, the page design, information update, and efficient service of the community will affect users' experience. Good community quality will make users feel that their payment behavior is useful, easy to operate, and valuable. However, when users pay for knowledge, they will feel fun and happy depending on the content paid for knowledge and community communication. Perceived value has a significant impact on perceived usefulness and perceived ease of use. For users, they have spent time, money, and energy in paying for knowledge in the community. As long as these efforts are valuable and meaningful, they will feel that the paid-for knowledge service provided by the community is useful and convenient. Expectation confirmation has no significant effect on perceived ease of use but has a significant effect on perceived playfulness. Users will have certain expectations about the services provided by the knowledge payment community before they pay for knowledge. In the actual process, once their expectations are satisfied, users' feelings of pleasure and satisfaction will be greatly improved, while the operation experience in the purchase process will not change much.

#### *The relationship between personal perception and community identity*

According to the research conclusions, perceived usefulness, perceived ease of use, and perceived playfulness all have a significant impact on community identity. In this study, community identity is divided into three dimensions, namely cognitive identity, evaluative identity, and emotional identity. Combining with the reality of life, it can be found that when users pay for knowledge, their personal feelings will affect the impression and evaluation of the community to a large extent, as long as users feel that their knowledge payment experience is useful, convenient, smooth, and happy. A certain identification with the community will increase the user's overall cognition and emotional attitude evaluation of the community and enhance their loyalty to the community.

### ***The relationship between community identity and willingness to pay***

This study believes that community recognition will have a significant impact on willingness to pay. If a user recognizes the community in the process of paying for knowledge, then he will feel that he belongs to the community, and his communication in the community is happy and can effectively solve their own problems. More importantly, they are important and valuable to the community in their heart. This cognitive and evaluative recognition will promote emotional recognition among users, who feel that they are doing a good thing by paying for knowledge in a community and are more than happy to recommend it to others. This recognition of the community will constantly strengthen users' willingness to pay for knowledge, thus promoting users' next payment behavior.

### **Management Implications**

Based on the above conclusions, this study puts forward the following suggestions for relevant operation managers of the knowledge payment community.

Pay attention to the quality of knowledge paid community and user-perceived usefulness. Users want to obtain the knowledge payment service they want in a convenient and effective way, so the knowledge payment community should pay attention to the improvement of community quality. The community quality of knowledge payment can be divided into system quality, information quality, and service quality, among which information quality and service quality have more influence on community quality, indicating that users are eager to find useful information and knowledge in the knowledge payment community and enjoy convenient and comfortable service. In terms of system quality, the premium knowledge payment community should be able to run stably, the page browsing is normal, and it can respond to users' operations and demands in time so that users can quickly obtain the required information. In terms of information quality, the community should provide users with comprehensive and complete information, ensure the real-time and accuracy of the information, and update the community information knowledge base in time. In terms of service quality, the knowledge payment community should timely optimize the relevant functions of the community, provide professional services for users, smoothly meet the knowledge needs of users, and constantly improve the ability to solve problems.

Enhance the output capacity of high-quality content in the community, and improve users' perceived value and community experience. Focusing on user community experience and perceived value can effectively improve users' willingness to pay for knowledge, and enhance the community's output capacity of high-quality content can be improved from two aspects of content selection and content management. Content selection, the community should pay attention to the source of output content, strictly screen the knowledge contributions of the community's knowledge producers, and improve the content review qualifications for fixed-column content providers in the community, establish reasonable and scientific content evaluation system. Community collaborators should also raise the barriers to entry for cooperation, strictly control the output content of the community, and improve the professionalism and accuracy of community knowledge. The content management, the community, should conduct high-quality and refined management of content, establish and classify related content, set up a reasonable column and scientifically optimize the column structure, continue to meet users' personalized knowledge needs and perceived value, and enhance the user community Experience and loyalty, thereby enhancing the value of community content and competitive advantage.

Improve public praise and create a good community image. Relevant empirical research proves that word-of-mouth communication of knowledge payment also has an impact on users' willingness to participate. Most of the users who participate in knowledge payment are young, pay attention to the acquisition of information, and are easily influenced by people around them. The opinions and word-of-mouth spread of people around can affect their perception of usefulness to a certain extent, thus affecting their willingness to pay. Therefore, the knowledge paying community should pay attention to the social dissemination of word of mouth through various information publicity channels, actively spread the good atmosphere of the community, use opinion leaders to carry out publicity cooperation, establish the effective word of mouth dissemination incentive mechanism, create a good social image of the community.

### **Research Limitations and Future Prospects**

This paper mainly studies the influencing factors of users' willingness to pay for knowledge in the context of the virtual brand community. Although some conclusions have been drawn, there are still deficiencies in many aspects of research. The following summaries are made, and prospects are made for subsequent studies.

In this study, due to the many limitations of sample collection, most of the survey subjects involved are college students, and there is a certain proportion of imbalance. In real life, the college student group is only a small part of the representatives of the participants who pay for knowledge. It will affect the research conclusions to a certain extent, and the sample interpretation ability needs to be improved. In future studies, the range of samples can be expanded to make research results more representative and accurate, and big data can also be used to obtain more data support to enhance the scientific nature of the research.

This study selected limited variables when constructing a model of the factors affecting users' willingness to pay for knowledge in the context of virtual brand communities. There are many different influencing factors of users' behavior and willingness to participate in different contexts. This study only considers some variables in the context of community and individual, and the selection of model variables is insufficient. In addition, the actual factors such as the personal characteristics, educational

background, and income of the participating users will also affect the willingness to participate to a certain extent. This is not considered in this study, and the population is not distinguished. In future research, more relevant factors will be introduced in the research content, and the research model will be continuously improved, with a view to drawing more representative research conclusions and more comprehensively exploring the factors affecting users' willingness to pay for knowledge in the context of virtual brand communities.

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## Review of Neural Network Algorithms

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### ABSTRACT

The artificial neural network is the core tool of machine learning to realize intelligence. It has shown its advantages in the fields of sound, image, sound, picture, and so on. Since entering the 21st century, the progress of science and technology and people's pursuit of artificial intelligence have introduced the research of artificial neural networks into an upsurge. Firstly, this paper introduces the application background and development process of the artificial neural network in order to clarify the research context of neural networks. Five branches and related applications of single-layer perceptron, linear neural network, BP neural network, Hopfield neural network, and depth neural network are analyzed in detail. The analysis shows that the development trend of the artificial neural network is developing towards a more general, flexible, and intelligent direction. Finally, the future development of the artificial neural network in training mode, learning mode, function expansion, and technology combination has prospected.

*Keywords:* Neural network, machine learning, review.

### INTRODUCTION

Modern computers work on the basis of Von Neumann's principle through program access. It can be used to solve programmable problems with clear features, reasoning, and operation rules efficiently. Its precision and speed in numerical and logical operations greatly expand the capacity of the human brain. Since the 21st century, computer networks have been rapidly developed and popularized. While enjoying the convenience brought by computer networks, people have put forward new requirements for the development of computer networks, and the voice of replacing the brain with a machine is getting higher and higher. However, because the traditional von Neumann's machine is limited to logical operation rules. The solution of unstructured problems is far from reaching the level of human intelligence. With the rapid development of modern information science and technology, this problem is becoming increasingly acute, which urges scientific and technical experts to find a new way to solve the problem. When people's thinking turns to the study of the human brain structure model and information processing mechanism, it promotes the in-depth development of brain science and the research of artificial neural networks and brain models. With an in-depth understanding of the biological brain, the artificial neural network has made great progress.

The artificial neural network is a mathematical model or computational model composed of a large number of artificial neurons, which imitates the corresponding structure and related functions of the biological brain. It is based on the basic principle of neural networks in biology. After understanding and abstracting the structure of the human brain and the response mechanism of external stimuli, it simulates the neural system of the human brain to process complex information based on the knowledge of network topology. The model is characterized by high fault tolerance, intelligence, adaptability, and self-learning. As an important algorithm and model to realize machine learning tasks, it has been successfully applied in the technical fields of handwriting recognition, speech recognition, image recognition, and natural language processing.

The research of artificial neural networks provides a way for machine learning subjective and informal knowledge and brings unprecedented expectations to the research of artificial intelligence. The research chain of "neural network — machine-learning — artificial intelligence" has become the core of a new round of sci-tech revolution and industrial reform and is having an extremely profound impact on the world economy, social progress, and people's life. In terms of the world economy, artificial intelligence is a strategic technology leading the future. The development of artificial intelligence has become a major strategy for major countries in the world to enhance national competitiveness and promote national economic growth. In terms of social progress, intelligent technology provides new technologies and ideas for social governance. The application of artificial intelligence in social governance is the most direct and effective way to reduce governance costs, improve governance efficiency and reduce governance interference. In terms of daily life, deep learning, image recognition, speech recognition, and other technologies have been widely used in intelligent terminals, smart homes, mobile payments, and other fields. In the future, artificial intelligence technology will also play a more significant role in education, medical treatment, travel, and other fields closely related to people's lives and provide life services with wider coverage, a better experience for ordinary people.

### DEVELOPMENT PROCESS OF NEURAL NETWORK

The starting point of neural network development is the MP model. In 1943, psychologist W.S. McCulloch and mathematical logician W. Pitts established a neural network and mathematical model, which is called the MP model. They put forward the formal mathematical description and network structure method of neurons through the MP model and proved that a single neuron could perform logical functions, thus creating an era of artificial neural network research.

In the 1960s, the concept of perceptron and adaptive linear elements further promoted the development of the artificial neural network. The perceptron is a structure composed of two layers of neurons. The function of the input layer is to receive external input signals. The output layer is also called the function layer, which is MP neurons. Because it has only one layer of functional neurons, it can not deal with nonlinear separable problems, and its learning ability is limited. After carefully analyzing the functions and limitations of the single-layer neural network system represented by perceptron, M.Minsky *et al.* published perceptron in 1969, pointing out that perceptron can not solve the high-order predicate problem. The development of neural networks has fallen into a trough.

In 1982, J.J. Hopfield, a physicist at the California Institute of Technology, proposed the Hopfield neural network model, breaking the downturn in the field of neural network research. Hopfield neural network introduces the concept of "computational energy," expresses the problem to be solved with the state of network neurons, and makes the judgment of network stability. In 1984, he put forward the Continuous Hopfield neural network model (CHNN), which did pioneering work for the research of neural computers, created a new way for the neural network to be used in associative memory and optimization calculation and effectively promoted the research of neural network.

In 1985, Geoffrey Hinton and other scholars proposed the Boltzmann Machine (BM) and the improved Restricted Boltzmann Machine (RBM) in 1986. RBM is actually a two-layer neural network. On this basis, Depth Boltzmann Machine (DBM, stacked restricted Boltzmann machine) and Depth Belief Network (DBN, stacked restricted Boltzmann machine plus BP algorithm) are developed.

In 1986, Geoffrey Hinton, David Rumelhart, and Ronald Williams published an important paper, "Learning representations by back-propagating errors," in the journal *Nature*, and proposed a BP algorithm (error backpropagation algorithm). BP neural network algorithm greatly reduces the time required to train the neural network and makes the artificial neural network have the ability of self-study and generalization, but it also has obvious defects, that is, when the number of network layers is large, it is easy to fall into optimal local solution and overfitting. With the continuous development of technology, the advantages of the BP algorithm are prominent, which makes it not only a classic artificial neural network algorithm but also one of the most commonly used neural network models.

In 1986, in the book *Parallel Distributed Processing: Exploration in the Microstructure of Cognition* edited by Rumelhart and McClelland, they established the parallel distributed processing theory, mainly devoted to the micro research of cognition, and made a detailed analysis of BP algorithm, which solved the problem that there was no effective algorithm for weight adjustment for a long time. It can solve the problems that cannot be solved by the perceptron, answers the problem about the limitations of neural networks in perceptrons, and proves that the artificial neural network has strong computing ability in practice.

In 1989, Yann Lecun proposed a Convolutional Neural Network LeNet updated by reverse conduction. In 1998, Yann Lecun and his collaborators constructed a complete Convolutional Neural Network LeNet-5 and achieved success in handwritten numeral recognition. The success of LeNet-5 has attracted attention to the application of a convolutional neural network. Microsoft developed Optical Character Recognition (OCR) system using a convolutional neural network in 2003. Other application research based on Convolutional Neural networks has also been carried out.

In 2006, Geoffrey Hinton's research team used the Restricted Boltzmann Machine to model the continuous layer of a neural network, used the layer by layer pre-training method to extract the high-dimensional features in the model data, and later proposed the Deep Belief Network. This technique was then extended to many different neural network architectures by many scholars, which greatly improved the generalization effect of the model on the test set. At the same time, with the improvement of hardware computing power and algorithm, the hidden layer of the network can continue to increase, so the researchers represented by Hinton redefined the artificial neural network as deep learning and popularized it. Since 2011, the neural network has gained an overwhelming advantage in the benchmark test of speech recognition and image recognition. Moreover, because the structure of the Convolutional Neural Network is very suitable for image recognition, combined with those research results, it has also attracted people's attention again.

At present, there are many kinds of neural networks with different uses. The knowledge map of the current status of artificial neural network studies by Citespace software is shown in Figure 1, and the study focused on the following knowledge domains: BP neural network, genetic algorithm, support vector machine, forecast, machine learning, etc. Through the keyword analysis of relevant literature on the artificial neural network by CiteSpace software, the ten keywords with the highest citation frequency are obtained, as shown in Figure 2: backpropagation, knowledge base, genetic algorithm, support vector machine, classification, forecasting, machine learning, etc. The research concentration shown in the Figure 2 timeline shows that the research of artificial neural networks began to increase after 2007, entered prosperity after 2010, and continues to this day. The research trend benefited from 2006 when Hinton *et al.* proposed an effective strategy for training deep neural networks that not only improves the model accuracy but also greatly promotes the development of unsupervised learning. After 2010, the deep neural network has been widely used, especially in 2011, Microsoft's speech recognition system broke through the traditional speech recognition technology, and the advent of AlexNet in 2012 has brought a great breakthrough to the whole image recognition field, but also made the deep neural network sweep the whole field of artificial intelligence foreshadowing.



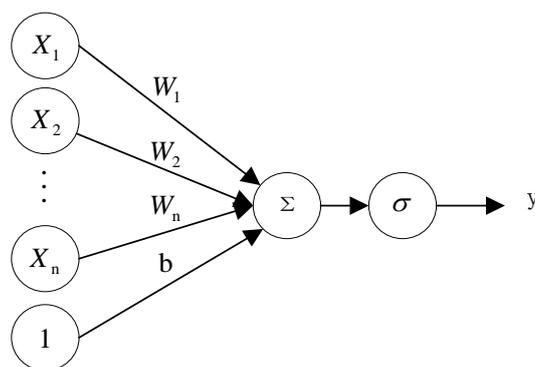


Figure 3: Single-layer perceptron model.

The Single-Layer Perceptron has the advantages of simple structure, a clear model, and a small amount of calculation. Since the activation function is a symbolic function, the output result  $y$  can only be two (0 / 1 or - 1 / 1). Therefore, Single-Layer Perceptron is mainly used to solve the linearly separable binary classification problem.

Due to the limitation of the structure of the perceptron, it has limitations in practical application. For example, the original Single-Layer Perceptron can only deal with linear separable problems. For linear non-separable problems, the algorithm will oscillate in the calculation process. That is, the algorithm can not stop. For the limitations of Single-Layer Perceptron, many scholars have proposed improved algorithms to improve the performance of Single-Layer Perceptron. One of the more famous is the Pocket Algorithm proposed by Gallant, that is, a pocket weight vector is introduced in the iterative process of PLA to store the perceptron weight vector with the correct runs, and its goal is to find a solution (optimal solution) with the least misclassification samples. Pocket PLA is a greedy approximation algorithm, which can deal with linear inseparable problems and better solve the noisy data and contradictory data in the samples.

The classical Single-Layer Perceptron has gradually withdrawn from the research field. At present, the research on Single-Layer Perceptron is mostly the research on the improved algorithm of Single-Layer Perceptron. However, as the simplest learning machine familiar to pattern recognition and neural network researchers, the classical perceptron algorithm is the basis of many complex algorithms developed later.

### Linear Neural Network

Linear Neural Networks are very similar to perceptron. The main difference is that the activation function can output only two possible values (-1 or 1), and the output of linear neural networks can take any value. Its activation function is a linear function. The adaptive linear neuron is the earliest typical representative of a linear network. It uses Widrow Hoff learning rule, that is, LMS (least mean square) algorithm, to adjust the weight and bias of the network. The criterion of the LMS algorithm is to minimize the expected value of the square ( $E\{e^2(n)\}$ ) of the difference between the desired signal and the actual output of the filter, and modify the weight coefficient vector  $W(n)$  according to this criterion.

Table 1: Single layer perceptron compared with the linear neural networks.

Comparison \ Classification	Perceptron	Linear Neural Network
Network transfer function	The perceptron transfer function is a binary threshold element, which determines that the perceptron can only do simple classification.	The transmission function of the linear neural network is linear, and it can also achieve fitting or approximation on a perceptron basis.
Learning algorithm	The perceptron learning algorithm stops just where it can correctly classify, making the classification boundaries too close to some modes and making the system sensitive to error.	The classification boundaries obtained by the LMS algorithm are often directly in the middle of the two classes of models.

The application of LMS learning makes linear neural networks different from Single-Layer Perceptron. However, based on the structural characteristics of a linear neural network, it can only deal with the linear mapping relationship of response input-output sample vector space and can only deal with the problem of linear separability. At present, a linear neural network is the most widely studied in the field of signal filtering. The application of an adaptive linear neural network algorithm improves the accuracy and robustness of the power system harmonic detection method. Through adaptive linear neural network training, the weights of multi-antenna transmitter security signal and artificial noise beamforming are obtained, which improves the security

of physical layer security output.

### BP Neural Network

Due to the simplicity of structure, the application of perceptron and linear neural networks is also limited to linear separable problems. With the in-depth study of neural networks, researchers improve the structure of the neural network and put forward the concept of a multilayer neural network. BP neural network is a multi-layer perceptron, which increases the number of network layers on the basis of the perceptron. The BP neural network model is shown in Figure 4. The network is composed of multiple layers, all layers are connected, and neurons in the same layer are not connected. In function, because it contains multiple hidden layers, BP neural network can mine more information from the input, has stronger network classification and recognition ability, and has the function of dealing with linear inseparable problems. In addition, BP adopts an error backpropagation algorithm for learning. Its main characteristic is that the signal propagates forward, and the error propagates back. Specifically, for the neural network model with only one hidden layer: the process of the BP neural network is mainly divided into two stages. The first stage is the forward propagation of the signal, passing through the hidden layer from the input layer to the output layer. The second stage is the backpropagation of error. From the output layer to the hidden layer, and finally, to the input layer, the weight and bias from the hidden layer to the output layer and from the input layer to the hidden layer are adjusted in turn. With continuous learning, the final error becomes smaller and smaller.

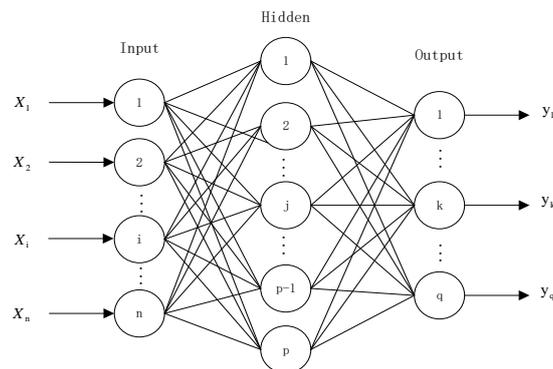


Figure 4: The BP neural network model.

In the BP neural network model, setting the input data from the input layer as  $X$ , the parameters from the input layer to the hidden layer as  $w$ ,  $b_1$ , the parameters from the hidden layer to the output layer as  $v$ ,  $b_2$ , and the activation function as  $f_1, f_2$ . So the model is set as:

$$\hat{y} = f_2(v^T f_1(w^T x + b_1) + b_2) \quad (2)$$

where the loss function is

$$E(\theta) = \frac{1}{n} \sum_{k=1}^q (y_k - \hat{y}_k)^2 \quad (3)$$

In the process of weight adjustment, there are

$$v^{(k)} = v^{(k-1)} + \eta \nabla_k v, \quad w^{(k)} = w^{(k-1)} + \eta \nabla_k w \quad (4)$$

BP neural network has the characteristics of multi-layer in structure and feedback in the algorithm, which makes it have strong nonlinear mapping ability and flexible network structure. The number of middle layers and the number of neurons in each layer of the network can be set arbitrarily according to the specific situation, and its performance varies with the difference of structure. However, in the process of specific application, BP neural network has no corresponding theoretical guidance in the selection of network layers and the number of neurons. Due to the large number of layers of the network, the error surface may contain multiple different local minima, and the gradient descent may lead to falling into the local minima. It is easy to overfit when the training times are too many and the spatial dimension is too high. For the problems of traditional BP neural networks, many scholars have studied the improved algorithm. Silaban *et al.* Applied BFGS Quasi-Newton to BP neural network and proposed that BP neural network with BFGS improved the convergence of the learning process, with an average improved convergence rate of 98.34%, and the accuracy will be improved when BFGS is used together with BP. Zhu *et al.* combined with Rumelhart's adding inertia pulse to dynamically adjust the learning rate can adjust the learning rate to a larger value so as to improve the learning speed of the model, affect the connection threshold and weight parameters of nodes through the learning rate, eliminate invalid iterations in the learning process of BP network, and combine the two to propose an improved algorithm to optimize BP network. It improves the local minimum value and the slow convergence speed of the traditional BP network. Ye *et al.* used a genetic algorithm to have excellent heuristic searchability in the multi-parameter optimization process and used a genetic algorithm to optimize the initialization of BPNN weight and threshold to make it approach the global minimum as much as possible.

At present, the network idea and algorithm model of the BP neural network are increasingly mature. The proposal and application of the improved algorithm improve the defects of the classical BP network. The variability of the network level enhances the flexibility of the network, which makes the application range of the BP neural network wider. Specific application fields include prediction and evaluation, pattern recognition and classification, data compression, etc.

The application of the BP neural network in prediction and evaluation is based on its characteristic of error backpropagation. The network weight and threshold can be adjusted according to the prediction error so that the prediction output of the BP neural network is close to the expected output. In terms of biological research, many scholars extract the surface characteristics of fruit, define the fruit defect and fruit decay, use BP neural network to fit the data, establish a defect-rot prediction model, and improve the average accuracy of fruit decay prediction. In terms of physics research, some scholars put forward a short-term wind electric power prediction algorithm (Improved Beetle Antennae Search, IBAS) optimization model of neural network parameters, introduced the Metropolis criterion into day cattle whiskers algorithm to reduce the probability of optimal local solution in the optimization process, so as to obtain the optimal initial weight and threshold of BP neural network, and improve the accuracy of short-term wind electric power prediction. In terms of engineering construction, the application of BP neural network prediction is conducive to solving the prediction problem under building regulation.

BP neural networks have strong pattern recognition capabilities through self-organized or learned-trained networks. Yin *et al.* used the characteristic parameters of underwater acoustic communication signals to build a modulation recognition system of underwater acoustic communication signals based on the BP neural network to realize the modulation recognition of underwater acoustic communication signals. Zhao *et al.* applied the trained BP network model to the actual cable trench safety monitoring system and used BP neural network to recognize the four common disturbance signals of optical fiber sensors. You *et al.* studied the hand motion pattern recognition of the BP neural network, introduced the cross-entropy cost function to improve the neural network so as to improve its learning rate, generalization ability, and the accuracy of motion classification.

The nonlinearity, fault tolerance, self-organization, and adaptability of BP neural network technology are widely used in data compression technology and greatly simplify the complexity of data compression. Zheng *et al.* used an artificial neural network to compress image data, and the network training time decreased significantly. BP neural network is applied to image compression of space fluid experiment, which achieves high compression ratio and good reconstructed image quality, and the trained network has high robustness. Chen *et al.* designed an improved BP neural network PID controller to adjust the parameters of the revolving door algorithm online to realize the adjustable precision of lossy compression. Through the simulation experiment, the best automatic precision lossy compression algorithm controller and its corresponding algorithm are determined.

### Hopfield Neural Network

Hopfield neural network is different from the three neural networks mentioned above. As a representative of the feedback neural network, Hopfield neural network has undergone fundamental changes in structure. The structure diagram of the Hopfield neural network is shown in Figure 5. All neurons have the same status without a hierarchical difference. They can be connected with each other or feedback signals to themselves, which have the characteristics of circulation and recursion.

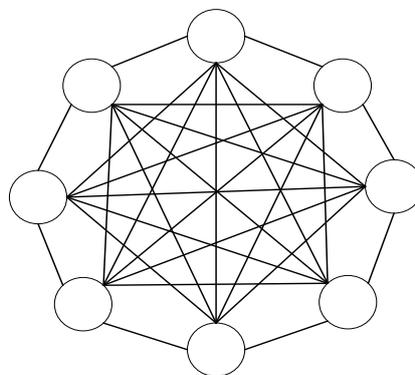


Figure 5: The Hopfield neural network model.

In the Hopfield network model, a Hopfield neural network composed of multiple units is set. The input of the  $i^{\text{th}}$  unit at time  $t$  is recorded as  $x_i(t)$ , the output is recorded as  $y_i(t)$ , the connection weight is  $w_{ij}$ , and the threshold is  $b_i(t)$ , then the output of the  $i^{\text{th}}$  unit at time  $t+1$  can be expressed as  $y_i(t+1)$ :

$$y_i(t) = \begin{cases} 1 & x_i(t) > 0 \\ y_i(t) & x_i(t) = 0 \\ 0 & x_i(t) < 0 \end{cases} \quad (5)$$

$$x_i(t) = \sum_{j=1}^n w_{ij} y_j(t) - b_i(t) \quad (6)$$

Hopfield's learning rules are based on indoctrination learning. That is, the weight of the network is not trained but calculated according to certain rules. Once the weight is determined, it will not change, and the state of each neuron in the network is constantly updated during operation. When the network evolves to a stable state, the solution to the problem is the state of each neuron. The characteristics of the Hopfield network are related to the introduced energy function  $E$ .

$$E = -\frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n w_{ij} y_i y_j + \sum_{i=1}^n b_i x_i \quad (7)$$

By observing the equation, it can be seen that the energy function  $E$  is always non-increasing. That is, it decreases gradually with the increase of time until the network reaches a stable state. When the input mode is consistent with the output mode, the result of the energy function  $E$  is 0.

Hopfield network can be divided into discrete and continuous network models according to different activation functions. The discrete model uses the hard limit function as the activation function, while the continuous model uses the sigmoid function as the activation function. The discrete network can converge to a stable equilibrium state and take it as the memory information of the sample. It has the ability to recall the complete memory information from a piece of incomplete information, so it is suitable for associative memory. However, the capacity of this associative memory is limited, and it is prone to a pseudo-stable point. When the memory samples are similar, the network can not recall the correct memory. By taking the energy function as the objective function, the continuous network corresponds to the optimization problem and is suitable for dealing with related problems.

For the application research of Discrete Hopfield Neural Network, karbasi *et al.* discussed that the internal noise of associative memory could improve the ability of associative memory when the memory mode does not reduce to a fixed threshold with the noise. Li Ya *et al.* combined memristor with traditional Hopfield neural network designed a memristor Hopfield neural network circuit. Danesh *et al.* studied emotion detection using a recursive auto-associative memory network by collecting speech, tags, and other data from social networking sites. For the research on the optimization of Discrete Hopfield Neural Network, Mofrad *et al.* embedded the coding technology into neural associative memory to improve the network recovery ability. Tanaka *et al.* proposed a Hopfield associative memory network with sparse modularization, introduced an iterative learning algorithm that depends on the network topology to change the connection weight and concluded that the network could have better associative memory ability only when the number of connections of each neuron is relatively consistent. Zhu *et al.* proposed a new learning method of network weight, replacing SGN with a linear function, and proved that the improved method has a great improvement in associative memory.

Hopfield (1984) successfully applied the continuous neural network model to the traveling salesman problem for the first time, which opened the door of a continuous Hopfield network in dealing with optimization problems. GARCÍA L *et al.* Studied the Hopfield neural network algorithm for optimizing topological mechanisms. Chen *et al.* designed a logistics path planning scheme based on a continuous Hopfield network, mapped the objective function of path optimization into the energy function of the network, designed the dynamic equation of the objective function, and obtained the optimal value of path planning by finding the minimum value of the equation. Wang *et al.* used the continuous Hopfield neural network algorithm for route optimization design, comprehensively considered the constraints of route freight rate and distance, mapped the optimal solution of the problem to the stable state of the neural network, and finally obtained the route optimization scheme with the lowest freight rate per unit distance.

Hopfield neural network makes machine learning tend to the function of the human brain, widens the research road in the field of machine learning, and puts forward higher requirements for a deep neural network.

### Deep Neural Network

The branch of the neural network mentioned above belongs to the traditional artificial neural network. Compared with a biological neural network, it is a shallow structure, which is far from human brain intelligence. With the improvement of computer processing speed and storage capacity, the design and implementation of a Deep Neural Network have gradually become possible. In the research field of the deep neural network, Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN) are more studied.

The recurrent neural network is mainly used to process sequence data. Because the hidden layer of RNN is cyclic, as shown in Figure 6, its biggest feature is that the output of neurons at a certain time can be input to neurons again. This series network structure is very suitable for time series data and can maintain the dependency in the data. The expanded RNN is a repeated structure, and the parameters in the network structure are shared, which greatly reduces the neural network parameters to be trained. On the other hand, shared parameters also enable the model to be extended to data of different lengths, so the input of RNN can be an indefinite length sequence. Although the purpose of RNN at the beginning of design is to learn long-term dependence, due to the iterative nature of standard RNN, it is often difficult to save information for a long time.

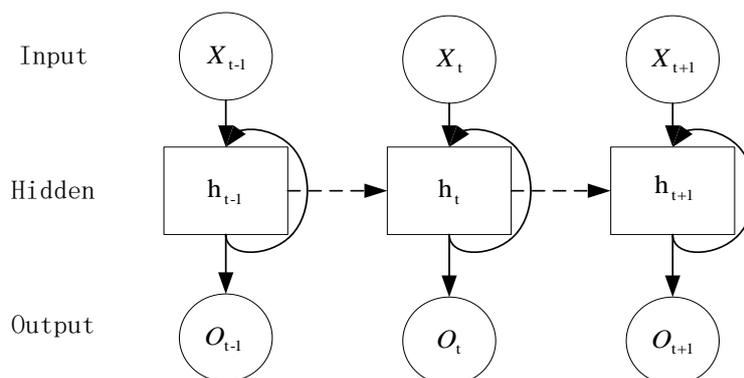


Figure 6: Recurrent neural network structure.

The LSTM proposed by Hochreiter *et al.* is improved on the basis of RNN, which can effectively overcome the gradient disappearance problem in RNN, especially in long-distance dependent tasks. Due to its excellent properties, LSTM has been used in a large number of tasks related to sequence learning. Wei *et al.* applied MLP, RNN, LSTM, and Gru to Pore Water Pressure (PWP) respectively, and concluded that the model with RNN structure is more accurate than MLP for time series data, especially LSTM and GRU can describe the time-delay effect between input and response, which is more accurate and reliable than standard RNN. Bai *et al.* combined RNN with CRFID for the intelligent library, predicted readers' perceived needs at different stages through readers' borrowing records and borrowing behavior, and provided readers with book purchase and personalized services. The actual data recorded by the library confirmed that the model was feasible to sense readers' needs at different stages. Palangi *et al.* use LSTM to learn the sentence vector with semantics and use the feature vector for the document retrieval task in the network. The hidden layer of the network provides the semantic representation of the whole sentence and can detect the keywords in the sentence. Miyamoto *et al.* introduced a language model based on BLSTM, which can adaptively mix word and character level word vectors to obtain the final word vector representation. Mikolov *et al.* proposed a new RNN based language model (RNN LM), which can be applied in speech recognition. Compared with the back-off language model, the confusion can be reduced by about 50% by using mixed models of several RNN LMS. Google uses LSTM for speech recognition on its smartphones and Google translation.

In terms of application, it can be seen that the Recurrent Neural Network has made remarkable achievements in processing sequence data applications such as text, audio, and video, which is of great significance to promoting the development of machine learning and artificial intelligence.

Convolutional Neural Network is a common network in machine learning. It is one of the most widely used deep neural networks. A typical Convolutional Neural Network consists of five parts: input layer, convolution layer, pooling layer, full connection layer, and output layer. The convolution layer is responsible for extracting local features in the image. The pooling layer is used to greatly reduce the parameter order (dimension reduction). The full connection layer is similar to the part of a traditional neural network to output the desired results. Because the pooling layer can reduce the data dimension, it can not only greatly reduce the amount of computation in the process of image recognition but also effectively avoid overfitting. With the continuous development of a convolutional neural network, the number of hidden layers increases gradually, including activation layer, normalization layer, tangent layer, fusion layer, and so on. In the activation layer, the relu activation function is used to introduce nonlinearity into the network, and the output result of the convolution layer is nonlinearly mapped. The image is segmented by cutting layers, and a part of the region is studied independently. The fusion layer can fuse the tangent layers or the features learned by convolution kernels of different sizes. Based on the processing function of the hidden layer, the convolutional neural network can realize powerful applications in the field of image processing.

Convolutional neural networks are widely used in the fields of image recognition, semantic segmentation, and machine translation. Lou *et al.* applied vgg16 and CNN to face recognition, collected the discarded image information, and applied it to the original CNN. The performance of the improved model is significantly improved compared with the ICA algorithm and traditional convolutional neural network. Hu *et al.* used CNN for image diagnosis. After the CT image was manually marked by experts, the mask R-CNN (Regions with CNN) was used to automatically cut the lung in the CT image. In the experiment, mask R-CNN and K-means are combined to obtain the best segmentation effect compared with other methods. The segmentation accuracy is  $97.68\% \pm 3.42\%$ , and the average running time is 11.2 s.

As a kind of artificial neural network, Convolutional Neural Network contains many networks with different structures. The early convolutional neural network structure is relatively simple, such as the Le Net-5 model. It is mainly used in handwritten character recognition, image classification, and other relatively single computer vision applications. With the deepening of research, the structure of the Convolutional Neural Network is continuously optimized, and its application field is gradually extended. As an unsupervised generation model, Convolutional Deep Belief Network (CDBN), which is generated by the combination of Convolutional Neural Network and Deep Belief Network (DBN), has been successfully applied to face feature extraction. Alex Net has made a breakthrough in the field of massive image classification. R-CNN has achieved success in the

field of target detection. A fully Convolutional Network (FCN) realizes end-to-end image semantic segmentation and greatly surpasses the traditional semantic segmentation algorithm in accuracy. In recent years, the research on the structure of the Convolutional Neural Network is still very hot. With the continuous improvement of network structure and performance, Convolutional Neural Network has emerged in various fields.

The research shows that the development of the neural network is in the spiral stage. The newly proposed or improved neural network can improve or expand the application of the previous neural network, but it can not completely cover the previous neural network. Networks with different structures have their own advantages and limitations in dealing with different problems. For this reason, analyzing neural networks from different perspectives will promote their improvement in structure and function.

### CONCLUSIONS AND OUTLOOK

As one of the most popular research directions in the field of machine learning, the neural network has attracted people from all walks of life to study and develop it continuously. This paper summarizes the development process of the neural network and introduces the development and research status of each branch of the neural network. It can be found that the development of the neural network is becoming more general, flexible, and intelligent, which is mainly reflected in the following four aspects. (1) The change of model structure and the optimization of the algorithm. (2) The exploration efficiency of neural networks in complex scenes is gradually improving and has achieved good performance in some difficult tasks. (3) Deep neural network is trying to simulate the working model of a human brain-assisted learning system in order to construct a model of autonomous memory, learning, and decision-making. (4) The progress of technology and equipment provides an objective guarantee for the research and development of the network.

In the future, neural networks will develop in the following directions. (1) They tend to train networks through incremental and combined learning methods, and hybrid neural networks will be more widely used. (2) Unsupervised learning neural network is closer to the processing mechanism of the human brain and will play a more important role in the development of the neural network. (3) Further strengthen the inspiration of cognitive neuroscience on a neural network to gradually master the functions of memory, focusing, planning, learning, and understanding possessed by the human brain. (4) Transfer learning will be more applied to network models to alleviate the lack of training data in real task scenarios. (5) With the help of cloud server-side multi-task collaborative learning will become a new trend.

It can be predicted that, with the development of hardware technology and the continuous deepening of the research on neural network theory and methods, more opportunities and challenges will usher in the development of the artificial neural network. In iterative updates, the application of artificial neural networks will be more and more extensive and more mature. In the field of artificial intelligence and others, the development of neural networks will continue to surprise people. Humans will achieve the ideal goal of "solving intelligence and solving everything with intelligence" in the near future.

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## Size does Matter: How do Micro-influencers Impact Follower Purchase Intention on Social Media?

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### ABSTRACT

Social media influencers have become a significant source of information for customers and a prevalent marketing tool for brands. It is crucial to explore factors that affect the follower's purchase intention of the products endorsed by social media influencers. Recently, micro-influencers have gained recognition for their authenticity and relatability when compared with their established counterparts, such as macro- or mega-influencers. Increasing organizations also see the value micro-influencers can bring to their brands via more interaction with their target customers. Based on the parasocial interaction theory, we propose that the perceived credibility and transparency of micro-influencers enhance followers' purchase intention through the mediation of parasocial interaction. Parasocial interaction is a kind of psychological relationship in which followers consider influencers as their friends, regardless of their limited interactions with those influencers. Our findings indicate that parasocial interaction between micro-influencers and their followers positively impacts purchase intentions of recommended products. It is also found that perceived micro-influencer credibility and transparency positively affect followers' parasocial interaction with micro-influencers. Implications of our findings are discussed.

*Keywords:* Micro-influencer credibility, micro-influencer transparency, influencer marketing, parasocial interaction, micro-influencers.

### INTRODUCTION

A surge in the need and willingness for online shopping has been witnessed since the pandemic (Grashuis *et al.*, 2020; Repko, 2020). Given the unlimited online space and low entry barriers to the internet, there tends to be an unconstrained growth of options for consumers to shop on the internet (Wareham *et al.*, 2014). Further, people can easily and sometimes unconsciously contribute to the production and/or dissemination of unverified and misleading information about brands or products (e.g., fake reviews) (Wu *et al.*, 2020). This leads to consumers anxiously spending a large amount of time and effort evaluating the credibility of online information and brands struggling to reach their target audience. The emergence of social media influencers has helped both consumers and brands to address these problems.

Individual social media influencers could have different scales of followers (Britt *et al.*, 2020). The market has long been dominated by mega-influencers (>1 million followers) for the massive traffic they could generate. Yet, in recent years, more brands are reaching out to micro-influencers, who have between 10k to 100k followers (Britt *et al.*, 2020; Chen, 2016). Micro-influencers are argued to be more relatable and authentic (Britt *et al.*, 2020). They are found to generate higher follower engagement and conversion to purchase rates (Williams, 2019). Apart from this, micro-influencers can be a better option for small to medium enterprises (SMEs) who cannot afford to collaborate with commercial mega-influencers who usually charge a hefty amount of money for their endorsement of brands (Boerman, 2020).

Micro-influencers have fewer followers and less human brand equity to leverage. However, they tend to be seen as more trustworthy and relatable and engage more with their followers than celebrities or mega-influencers do (Williams, 2019). The majority of existing literature on influencer marketing has not distinguished types of influencers and the mechanisms they apply to influence their followers (Liu *et al.*, 2021; Sun *et al.*, 2019; Xue *et al.*, 2020). Hence, this study aims to bridge this gap by investigating how micro-influencers impact followers' purchase intention from the perspective of parasocial interaction. Parasocial interaction is a kind of psychological relationship in which followers consider media personalities as their friends, regardless of their limited interactions with those media personalities (Gleich, 1997; Rihl & Wegener, 2019). We propose micro-influencer credibility and micro-influencer transparency will enhance parasocial interaction between micro-influencers and their followers, leading to followers' higher purchase intention. To test this, we performed a survey on 217 followers of micro-influencers on social media platforms. Our results demonstrate the key role played by parasocial interaction in mediating the effects of micro-influencer credibility and micro-influencer transparency on followers' purchase intention.

The remainder of the paper is organized as follows. The next section reviews the literature and develops a framework that outlines why we believe parasocial interaction is the key to micro-influencers impact on follower purchase intention. We then detail our survey method. This is followed by findings and discussion. Finally, we conclude this paper.

### LITERATURE REVIEW

Social media influencers are individuals who shape audience attitudes and behaviors via the use of various social media. They can prompt direct follower behaviors such as “likes”, “comments”, or “share”, and affect followers’ opinions and decisions by sharing their own thoughts, feelings, or experience on fashion, travel, fitness, or even their daily routines. Social media influencers share similarities with traditional celebrities as they have both established their image as “human brands” (Ki *et al.*, 2020). Social media influencers can steadily draw the audience’s attention and engage them in interaction to enlarge their social reach and followership (Kay *et al.*, 2020).

Brands usually invite influencers to endorse their products by inviting them to promotional events, sending free products for testing, or even providing monetary compensation. This helps build up brand reputation and image among the influencers’ followers, who are often the potential customers (De Veirman *et al.*, 2017). Because of a seemingly spontaneous flow of their persona and style on the social media platform, influencer marketing tends to be perceived as more natural, authentic, and real than branded ads (Campbell & Farrell, 2020; Evans *et al.*, 2017).

However, social media influencers can differ in their scale of followership. Prior studies suggest a two-level (i.e., mega- and micro-influencer) (Britt *et al.*, 2020; Schouten *et al.*, 2020), three-level (i.e., mega-, macro- and micro-influencer) (Porteous, 2018), four-level (i.e., mega-, macro-, micro- and nano-influencer) (Isyanto *et al.*, 2020), and even five-level classification (i.e., celebrity, mega-, macro-, micro- and nano-influencer) (Campbell & Farrell, 2020). For example, according to Campbell and Farrell (2020), celebrity influencers who gain public recognition outside of social media normally have over a million followers; mega-influencers who have experienced significant follower growth on social media because of established expertise have 1m+ followers; macro-influencers own 100k to 1m followers; micro-influencers have between 10k – 100k followers; and nano-influencers has less than 10k audience who are mainly families, friends, and acquaintances.

Influencers with a larger scale of followers attract brands for their large reach, fame, and leadership in expressing opinions (De Veirman *et al.*, 2017). They typically charge a higher price for endorsement. In comparison, micro-influencers (with 10k-100k followers), which are the focus of this study, have gained the attention of brands and scholars recently for that they show even a higher level of engagement rate with audiences (6.3% vs. 3.6%) (Williams, 2019) and charge much less than influencers with larger followership (Britt *et al.*, 2020). Some micro-influencers even accept the exchange of their endorsement for free products and gifts (Kay *et al.*, 2020). Britt *et al.* (2020) found that micro-influencers are more likely to engage in direct, two-way dialogue with their followers. Therefore, they are more likely to disseminate valued product information to their followers and persuade them to purchase products endorsed by them.

#### Parasocial Interaction

Para-social interaction describes a kind of relationship between the audience and media figures in which the audience develops an illusion of perceived intimacy with the figures (Gleich, 1997). This relationship is self-established, and the other person may not know it and impact it (Horton & Richard Wohl, 1956). Parasocial interaction is not a mutual relationship, but the audiences interact with the personas as if they are with them and as if it is based on two-way communication. This kind of relationship can even develop to the degree to which the audience starts to view the performer as “real friends”, fostering through multiple interactions in the long term (Russell *et al.*, 2006).

Users of social media sites can establish a parasocial relationship with influencers through subscribing to their accounts or channels and constantly keeping themselves updated with influencers’ posts on social networking sites (Rihl & Wegener, 2019). As a result, followers can know the influencer, engage with the influencer, form attachment toward the influencer, and generate feelings of closeness (Boerman, 2020).

Micro-influencers are considered to be more authentic and trustworthy than their celebrity or popular counterparts, who are increasingly prone to consumer skepticism about the sincerity of their endorsements and their intention to manipulate the follower (Britt *et al.*, 2020; Chen, 2016). Micro-influencers can adopt specific strategies or take advantage of their attributes to induce positive emotions (e.g., perceived intimacy) within their followers to further influence their purchase intention. For example, celebrities or popular influencers who have a long history of interaction with their followers can use affective content to arouse followers’ positive emotional reactions (Britt *et al.*, 2020). However, unlike their popular counterparts, it is found such an emotion-laden message can be detrimental for micro-influencers. Instead, followers tend to be drawn to micro-influencers initially for the credible and professional content they provide (Britt *et al.*, 2020; Djafarova & Trofimenko, 2019).

Furthermore, the prevalent practice of sponsored endorsements makes it crucial to investigate whether clear disclosure of endorsement relationships with brands (i.e., transparency) can stimulate social media influencers’ interaction with their followers. Prior studies found disclosure by mega-influencers could stimulate more liking, sharing, and comments on the posts (Boerman, 2020). However, the effect of disclosure on micro-influencers is inconclusive (Boerman, 2020; Evans *et al.*, 2017;

Johnson *et al.*, 2019). We thus argue micro-influencer credibility and micro-influencer transparency are key factors contributing to followers' parasocial interaction with micro-influencers. Figure 1 is our conceptual research model:

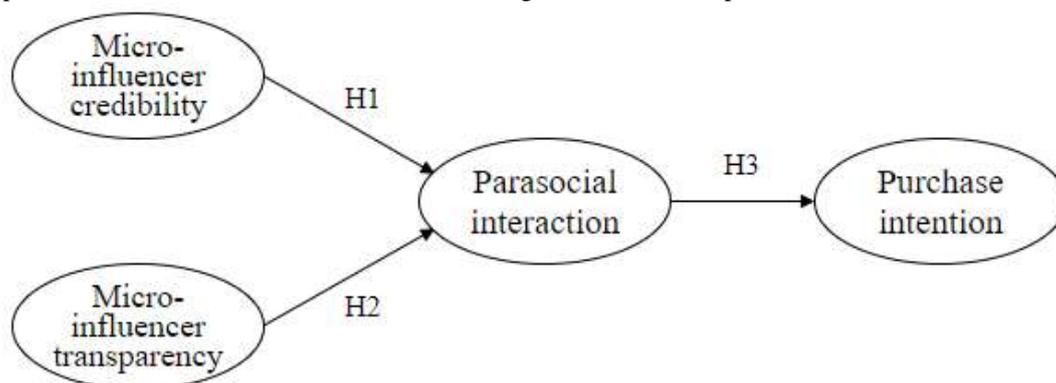


Figure 1: Conceptual research model

### Micro-influencer Credibility

Micro-influencer credibility refers to the level of trustworthiness and reliability of the micro-influencer as perceived by its followers (Sokolova & Kefi, 2020). It involves the recognition of a micro-influencer on whether a claim s/he makes is true, genuine, and unprejudiced (Chetioui *et al.*, 2020). Perceived credibility has been found to play a vital role in explaining the effects of influencer marketing, and it is likely to affect the audience's attitudes and behaviors (Schouten *et al.*, 2020). Several studies examined the effects of influencer credibility on consumers' attitudes towards the brand and the influencer. For instance, Chetioui, Benlafqih, and Lebdaoui (2020) investigated the contribution of fashion influencers to consumers' purchase intention. They found that perceived credibility was the most conclusive factor among a set of influencer characteristics. They also found that when a brand is recommended by credible influencers, customers are more willing to recommend the brand to others.

Perceived credibility has also been recognized to be one of the most significant factors when selecting which influencers to follow and interact with (Nam & Dân, 2018). Xiao, Wang, and Chan-Olmsted (2018) argued that influencers do not only have the power to directly influence the purchase decisions of a large audience, but their followers also judge them to be reliable information sources to interact with. Chapple and Cownie (2017) also found consumers regularly follow lifestyle vloggers' product recommendations because they considered these vloggers as credible sources of information.

People used to follow influencers with greater followership because of their attractiveness and assumingly more trustworthy (Kay *et al.*, 2020). Yet, as the number of followers increases, the engagement for those influencers tends to drop. Chen (2016) describes the scale of followership of micro-influencers (between 10k-100k followers) as the "sweet spot" in which micro-influencer can afford better engagement in direct and two-way communication and build a greater personal connection with their followers (Sokolova & Perez, 2021). Increasingly people and brands have turned to micro-influencers over celebrities and commercial influencers for that micro-influencers are more interactive and responsive to their followers. Djafarova and Trofimenko (2019) found that people tend to follow and interact with micro-influencers on Instagram who post credible blogs or videos to engage them.

Consequently, we suppose that followers who regard micro-influencers as a source of reliable information are more likely to build and engage in a parasocial relationship with them. Hence:

*H1: Micro-influencer credibility is positively correlated with followers' parasocial interaction with micro-influencers.*

### Micro-influencer Transparency

Micro-influencer transparency refers to followers' perceptions of whether the micro-influencer is honest about the products s/he recommends (Woodroof *et al.*, 2020). Influencer marketing is tightly connected with native advertising, in which micro-influencers imitate the form and flow of content on social media platforms so that consumers cannot easily detect their persuasive intentions. Prior studies about the effect of disclosures on advertising performance are inconclusive. For example, Boerman (2020) found that disclosure could generate positive effects, leading to followers' positive interpretation, more liking, sharing, or commenting on influencers' posts. In contrast, Evans *et al.* (2017) discovered a negative impact of disclosure, and Johnson, Potocki, and Veldhuis (2019) found no effect. However, Evans *et al.* (2017) and Johnson, Potocki, and Veldhuis (2019) do not differentiate types of influencers and examine their followers' reactions to well-known brands.

With customers' increasing knowledge about paid endorsements on social networking sites, they are more cognizant of influencers' persuasion languages and intentions. Indeed, Woodroof *et al.* (2020) found that when consumers are more knowledgeable about a paid endorsement, they are less likely to perceive the influencer as transparent or genuine if the influencer uses ambiguous disclosure language. They also noted that consumers tend to be confident that the quality of the promoted product is high and have more intention to purchase when they believe the influencer is transparent. Clear disclosure of the endorsement

relationship is an essential basis and value for building positive and interactive relationships between micro-influencers and followers. Thus, we propose the following hypothesis to be tested:

*H2: Micro-influencer transparency is positively correlated with followers' parasocial interaction with micro-influencers.*

### **Purchase Intention**

Purchase intention refers to the probability that a customer has the plan or willingness to buy a specific product or brand (Huang *et al.*, 2011). Prior studies found influencer marketing has a positive impact on consumer behaviors due to influencers' personal attributes, such as perceived credibility, physical attractiveness, or similarity (Chapple & Cownie, 2017; Djafarova & Trofimenko, 2019; Isyanto *et al.*, 2020; Sokolova & Kefi, 2020). However, it is unclear how those attributes lead to followers' purchase intention. Little literature has investigated the mediating effect of parasocial interaction (Hwang & Zhang, 2018; Rihl & Wegener, 2019; Sokolova & Kefi, 2020).

Social media platforms are perfectly suited for micro-influencers to develop parasocial interaction with their followers. On social media platforms, micro-influencers can constantly update their thoughts and feelings through blogs, videos, or other forms of content. In return, their followers can regularly view those contents and engage in imagined and effective interaction with the micro-influencers. As a result, followers will see micro-influencers as reliable friends and are willing to take their advice. In addition, parasocial interaction can create a halo effect (Liu *et al.*, 2021). Therefore, followers tend to see products endorsed by micro-influencers as reliable and authentic. Thus, we hypothesize:

*H3: Parasocial interaction is positively correlated to follower purchase intention.*

## **METHODOLOGY**

This study conducted a survey to investigate the impacts of micro-influencer credibility and transparency on their followers' purchase intention, which are mediated through followers' parasocial interaction with micro-influencers. We chose the food and beverage industry as the research context because the COVID-19 pandemic largely increased the online purchase of said product categories (Redman, 2021). Although small brands are more likely to choose micro-influencers to endorse their products (Bagby, 2018; Rannard, 2021), the food and beverage industry simultaneously has many big players and SMEs and their associated emerging new products and brands (Cruz, 2021; Frąckiewicz, 2018). This industry, therefore, is suitable for conducting our study.

The questionnaire consisted of two parts. The first part asked the questions regarding demographic variables of the respondents, including their gender, age, daily usage of social media, and monthly consumption level. The second part asked the respondents with 18 measurement items in terms of their perceived micro-influencer credibility, micro-influencer transparency, parasocial interaction with a micro-influencer, and purchase intention (see Appendix A). Respondents were asked to recall their favorite or most familiar micro-influencer who has only 10k – 100k followers and who they recently interacted with or watched on a social media platform. All items were measured on a five-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Micro-influencer credibility was measured by four items adapted from Yang, Kim and Yoo (2013). It assesses the extent to which the respondent perceives that the micro-influencer is trustworthy and credible.

Micro-influencer transparency was measured by four items adapted from Woodroof *et al.* (2020). It assesses the extent to which the respondent perceives the micro-influencers dependability, honesty, and believability.

Parasocial interaction was measured by seven items adapted from Russell, Stern, and Stern (2006). It evaluates the extent to which the respondent feels emotionally attached to the micro-influencer.

Purchase intention was measured by three items adapted from Evans *et al.* (2017). It assesses the respondent's intention and willingness to try the brands and related product lines endorsed by the micro-influencer.

We controlled for age, gender, and monthly spending to rule out rival explanations for our results. First, mature consumers mostly have a stronger purchasing power (Law *et al.*, 2016). As a result, they are more willing and capable to purchase products that they do not usually consume or experiment with new products or brands suggested by social media influencers. Second, prior studies suggest that there are gender differences in online participation and social media interaction (Morante *et al.*, 2017; Zhou *et al.*, 2014). Finally, high monthly spending means consumers are willing to spend and purchase more.

A link was published on popular Chinese social media platforms, including WeChat, QQ, and Weibo, to collect data. In total, 217 valid responses were received. Table 1 shows the characteristics of the respondents. About 87% of the respondents were between 18 and 31 years old. They are Generation Z (born between 1995 and 2009) and Generation Y (born between 1980 and 1994), who are the most active users of social media sites (Lissitsa & Kol, 2016; Priporas *et al.*, 2020; Sokolova & Kefi, 2020). About 70% of the respondents are female, which is aligned with many previous studies on influencer marketing (Sokolova & Kefi, 2020; Sun *et al.*, 2019; Xue *et al.*, 2020). For instance, 61.1% of the respondents were female in Sun *et al.* (2019) that

investigates the influences of live-streamers on viewers' purchase intentions. In Xue *et al.* (2020), the percentage of female respondents even reached 89.7% as females prefer to follow influencers on social media platforms and engage in online shopping. 43% of respondents reported that their daily usage was between two to four hours a day, accounting for the largest proportion in the survey, 35% for more than 4 hours per day, 18% for one to two hours, and 4% indicating they use social media less than one hour every day. Finally, 72.5% of participants reported that they had the experience of purchasing food and beverage products recommended by micro-influencers on social media.

Table 1: Characteristics of Respondents (N=217)

	Categories	Frequency	%
Gender	Male	66	30.4
	Female	151	69.6
Age	Under 18	2	0.9
	18-25	148	68.2
	26-31	39	18.0
	Above 31	28	12.9
Monthly Spending (USD)	Under 300	56	25.8
	301-600	108	49.8
	601-900	29	13.4
	Above 901	24	11.1
Daily Time Spent on Social Media	less than 1 hour	8	3.7
	1-2 hours	39	18.0
	2-4 hours	94	43.3
	above 4 hours	76	35.0

## DATA ANALYSIS AND RESULTS

A partial least squares (PLS) using SmartPLS 3.3.3 was conducted for measurement validation and hypothesis testing. PLS is appropriate for our study because it is recommended for the more exploratory foci of research objectives (Hair *et al.*, 2017a). This study explores influencer marketing which is still in its infancy (Britt *et al.*, 2020). In particular, we investigate consumer engagement with an emerging type of influencers (i.e., micro-influencers).

### Measurement Model

We assessed the reliability and validity based on the guidelines by (Hair *et al.*, 2017a; Hair *et al.*, 2017b). Outer loadings for all items were higher than 0.7 and significant at a 1% level except for one item of influencer transparency. We deleted such items from the research model. The rho\_A, composite reliability (CR), and Cronbach's alpha estimates (see Appendix B) were above 0.7, indicating good internal consistency and the reliability of all the scales. We further examined convergent validity using the average variance extracted (AVE) criterion (Hair *et al.*, 2017a). The AVEs of all constructs exceeded the minimum threshold value of 0.5 (see Appendix B), demonstrating sufficient convergent validity.

Discriminating validity was established by (1) the items loaded higher on the construct that they were intended to measure than those on other constructs; (2) the square root of the AVE by each construct was higher than the inner construct correlations; and (3) the heterotrait-monotrait ratio of correlation (HTMT) was significantly smaller than 1 (Henseler *et al.*, 2015). Our data showed that all the items loaded higher on their own construct than those on other constructs (due to page limit, cross-loading table provided by request). As shown in Appendix B, the square roots of AVE of all first-order constructs were greater than the absolute values of the correlation coefficient between the constructs. The HTMT values presented in the parentheses of Appendix B were significantly lower than 1, with a 95% confidence interval. These results indicated discriminant validity.

Common method variance (CMV) was tackled by two approaches. First, we used Harmon's single-factor test to assess CMV (Podsakoff *et al.*, 2003). Three factors with eigenvalue >1 were extracted and collectively accounted for 62.697% of the variances in the data, with the first factor accounting for 48.735% of the variances. No factors accounted for more than 50%. Second, we incorporated the measured latent marker variable (MLMV) in our survey to correct for CMV when using PLS (Chin *et al.*, 2012). This approach requires collecting multiple items that have no nomological relationship with the research items. We followed the guidelines introduced by Chin *et al.* (Chin *et al.*, 2012). We adopted the items used to measure "computer software usage habits" (Chin *et al.*, 2012) as marker variables. We then could conduct the construct level correction (CLC) to partial out the CMV effects at the structural model in our data analysis (Chin *et al.*, 2012). CLC involves creating as many CMV control constructs as there are constructs in the research model. Each CMV control uses the same entire set of MLMV items. CMV construct was modeled as impacting each model construct (Chin *et al.*, 2012). The results indicated that no change in the correlation signs of path coefficients and significances in our structural model. We thus concluded that CMV was not a serious problem.

### Structural Model

We first assessed multicollinearity by examining each set of predictor constructs separately for each subpart of the research model (Hair *et al.*, 2017a). In our research model, all the VIF of endogenous constructs were less than 2, which was well below the threshold value of 5 (Hair *et al.*, 2017a). This indicated there was no multicollinearity problem in our model. To assess the

significance of the path coefficients, a bootstrapping was applied to generate 10,000 samples with a PLS algorithm, no sign changes, a path weighting scheme, and a bias-corrected and accelerated bootstrap (Hair *et al.*, 2017a). The full model had an  $R^2$  of 50.8% for purchase intention.  $R^2$  for parasocial interaction was 49.2%. With an omission distance equal to 5, all the cross-validated redundancy  $Q^2$  values of endogenous constructs were higher than zero (0.288 for parasocial interaction; 0.303 for purchase intention), indicating that the exogenous constructs had predictive relevance for the endogenous constructs under consideration (Hair, *et al.*, 2017a).

As shown in Figure 2, the results demonstrate that micro-influencer credibility positively affects parasocial interaction, supporting H1 ( $\beta=0.500$ ;  $p < 0.001$ ). Micro-influencer transparency is positively associated with parasocial interaction, supporting H2 ( $\beta=0.271$ ;  $p < 0.001$ ). Parasocial interaction has a significant effect on purchase intention, thus supporting H3 ( $\beta=0.582$ ;  $p < 0.001$ ). Finally, about control variables, the impacts of gender on both parasocial interaction and purchase intention are insignificant. However, while age has positive effect on purchase intention ( $\beta=0.125$ ;  $p < 0.05$ ), the opposite result is reflected in monthly spending ( $\beta= -0.152$ ;  $p < 0.01$ ). This suggests that individuals who purchase more online may be immune to influencer marketing. Overall, we note support for all our hypotheses in the research model.

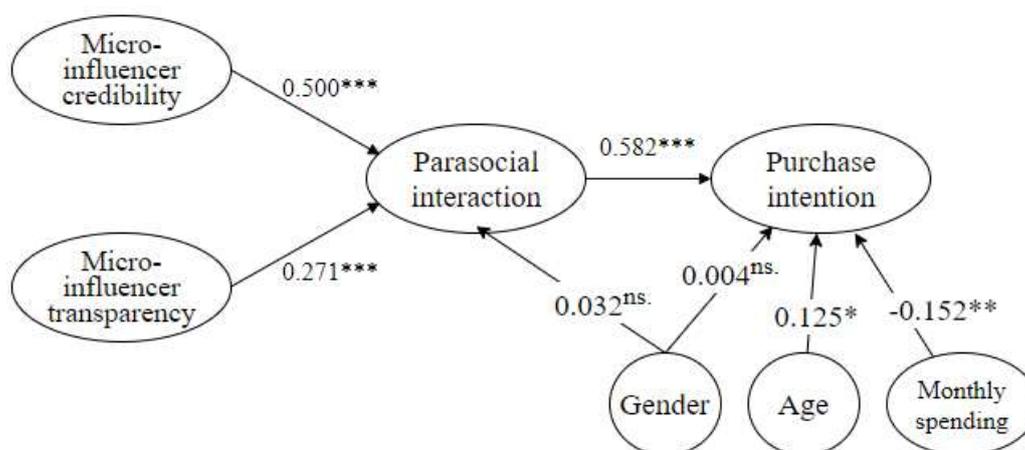


Figure 2: Structural model

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; ns. Not significant; Two-tailed test.

We further conducted a mediation test to examine the indirect effects of micro-influencer credibility and transparency on purchase intention through parasocial interaction. We followed the guidelines suggested by Hair *et al.* (Hair *et al.*, 2017a). A bootstrapping with a PLS algorithm, no sign changes, a path weighting scheme, and a bias-corrected and accelerated bootstrap were applied to generate 10,000 samples (Hair *et al.*, 2017a). The results are shown in Appendix C, and all the indirect effects are significant at the  $p < 0.01$  level. Because of the significance of the direct effect of micro-influencer credibility on purchase intention ( $\beta=0.308$ ;  $p < 0.001$ ), parasocial interaction partially mediates such a relationship. This suggests that without building up a high level of parasocial interaction, micro-influencers are still able to increase their followers' purchase intention by enhancing their credibility. Of course, such direct effect can also complement parasocial interaction to provide a stronger positive effect on followers' purchase intention. However, due to the insignificance of the direct effects of micro-influencer transparency ( $\beta=0.143$ ;  $p > 0.05$ ) on purchase intention, parasocial interaction fully mediates such a relationship.

## DISCUSSION AND IMPLICATIONS

Our findings provide support for the hypothesized research model and hypotheses. Our findings suggest that micro-influencer credibility and transparency encourage followers' parasocial interaction with the micro-influencers, which further leads to follower purchase intention. Prior studies focus on influencer attributes in influencing follower purchase intention (Isyanto *et al.*, 2020; Sokolova & Kefi, 2020). This study extends prior literature by demonstrating how those attributes may lead to followers' purchase intention through followers' parasocial interaction with micro-influencers. In mediated relationships, micro-influencer transparency is fully mediated by parasocial interaction, and micro-influencer credibility is partially mediated by parasocial interaction.

This study also suggests that micro-influencer credibility and micro-influencer transparency can be the key factors that followers are initially attracted to micro-influencers for developing parasocial interaction with them. Unlike their popular counterparts, who are naturally considered credible and honest, micro-influencers need to first earn and establish their credibility and transparency by demonstrating their expertise in specific domains and self-disclosure of endorsement relationships. As a result, viewers or potential followers will continue to follow the micro-influencers to further develop a parasocial relationship.

Moreover, our results suggest that micro-influencer credibility is more influential than their transparency. Statistically, micro-influencer credibility had a larger standardized path coefficient (0.500 vs. 0.271). Unlike celebrity or mega influencers who have a greater history of interaction with their followers, micro-influencers have to first establish their niches of impact in the already overcompetitive influencer marketing landscape. Therefore, micro-influencers need to initially rely on the credibility of messages to attract followers to form their niches of impact. This finding is congruent with Britt et al. (Britt *et al.*, 2020), in which they found that micro-influencers rely on the use of information-based messages (vs. emotion-laden ones) to establish a relationship with their followers. Subsequently, micro-influencer transparency can help followers navigate through the prevalent practice of mixing sponsored content with non-sponsored content by social media influencers.

Congruent with Boerman (2020) and Britt *et al.* (2020), our study demonstrates that micro-influencer transparency can create a positive effect on followers' reactions. Our study further indicates that the effect of micro-influencer transparency on follower purchase intention is fully mediated by followers' parasocial relationship with micro-influencers.

### CONCLUSIONS AND LIMITATIONS

This paper has demonstrated that micro-influencers can attract and engage their followers in parasocial interaction to influence their purchase intention. This study articulated and tested a conceptual model that posits micro-influencer credibility and transparency can help engage followers in parasocial interaction with micro-influencers to influence their purchase intention. We found that micro-influencer credibility is more influential than micro-influencer transparency in engaging followers in parasocial interaction with micro-influencers. Our study reveals the importance of parasocial interaction in influencer marketing effectiveness that involves micro-influencers rather than well-established social media influencers.

However, this paper has several limitations. First, our sample mainly comprises users of social media platforms in China, such as WeChat, Weibo, Xiaohongshu, and Bilibili. Thus, the generalizability of our model and findings on other social media platforms in different cultural contexts may require further investigation. Second, we only examined micro-influencers in the food and beverage industry. Future studies should investigate those in different industries, such as fashion or tourism, to see if our results hold. Third, our study relies on self-reports as the single data source. This may create common method bias. We thus tested for common method bias, and there was no statistical evidence of severe bias. Finally, our data were cross-sectional. Therefore, all the relationships in our study can only be tentatively concluded.

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## APPENDIX A: Constructs, Items, Means, Standard Deviations, and Sources

Constructs	Items	$\mu$	$\sigma$	Source
Micro-influencer Credibility	I do believe that this micro-influencer is convincing	3.44	0.78	Yang, Kim and Yoo (2013)
	I do believe that this micro-influencer is credible	3.24	0.81	
	I do believe that this micro-influencer's advertising is a good reference for purchasing food and beverages	3.5	0.92	
	I find purchasing food and beverages advertised by this micro-influencer to be worthwhile	3.14	0.88	
Micro-influencer Transparency	<i>If I wanted to, I could easily find out about the endorsement relationship in the posts of this micro-influencer (deleted due to outer loading lower than 0.7)</i>			Hustvedt and Kang (2013)
	This micro-influencer would be honest and sincere in promoting a certain brand or product	3.18	0.89	
	I can rely on this micro-influencer to post only brands or products [he/she] believes in	3.14	0.96	
	I can rely on this micro-influencer to post only brands or products [he/she] personally consumes	3.11	0.92	
Parasocial Interaction	I think the micro-influencer is like an old friend;	2.99	0.93	Russell, Stern, and Stern (2006)
	This micro-influencer makes me feel comfortable as if I am with a friend;	3.19	0.93	
	This micro-influencer seems to understand the things I want to know;	3.06	1.01	
	I find this micro-influencer to be attractive;	3.32	0.9	
	I would like to meet this micro-influencer in person;	2.69	1.13	
	I like to compare my ideas with what this micro-influencer says;	3.06	1.11	
	When I am on the blog, I feel as if I am part of the group	3.22	0.99	
Purchase Intention	I would like to try the brands endorsed by this micro-influencer	3.6	0.78	Evans <i>et al.</i> (2017)
	I would buy other products of this brand because of this influencer	3.2	1.02	
	I would actively seek out the products shown by this influencer in order to purchase it	3.45	0.97	

**APPENDIX B: Interconstruct correlations, Reliability measures, and HTMT**

	$\alpha$	$\rho_A$	CR.	AVE	Cred.	Tran.	Para. Inter.	Purch. Intent.	Marker
Micro-influencer credibility	0.84	0.84	0.89	0.67	<b>0.82</b>				
Micro-influencer transparency	0.81	0.83	0.89	0.73	0.69 (0.82)	<b>0.85</b>			
Parasocial interaction	0.90	0.90	0.92	0.61	0.67 (0.77)	0.61 (0.70)	<b>0.78</b>		
Purchase intention	0.71	0.71	0.84	0.63	0.68 (0.89)	0.61 (0.80)	0.66 (0.83)	<b>0.79</b>	
Marker	0.76	0.77	0.86	0.67	0.46 (0.57)	0.33 (0.40)	0.29 (0.33)	0.40 (0.53)	<b>0.82</b>

Note: (1) Square roots of AVE are presented on the diagonal. (2) HTMT are presented in the parentheses

**APPENDIX C: Significance analysis of the Direct and Indirect Effects**

Paths	Direct effect	t value	Indirect effect	t value	Mediation
Influencer credibility → Purchase intention	0.308	3.808***	0.161	3.79***	Partial mediation
Influencer transparency → Purchase intention	0.143	1.921 <sup>ns.</sup>	0.088	2.84**	Full mediation

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; ns. Not significant; Two-tailed test.

## Study on the Competency Model Construction for Industrial Designers under Artificial Intelligence Technology

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### ABSTRACT

As artificial intelligence (AI) technology is gradually put into application in the design industry, higher requirements have been imposed on the competence of industrial designers in the market. This study explored the application of AI technology in the design field and its future development direction on the basis of literature research in order to figure out the competency factors of industrial designers under the background of AI technology. Expert research and interview were used to obtain expert reliability, followed by a questionnaire survey of designers and data analysis to verify the effectiveness of the competency model, based on which the competency model of industrial designers in the AI context has been finalized. The result shows that it is necessary for designers to be capable of integrating and reserving cross-domain knowledge due to high demands on the degree of recognition to innovation ability, knowledge, and professional capability, and on the innovation of both design thinking and design method. Under the background of AI, industrial designers are required to understand the basic background knowledge of AI, and to have the ability to finish information sorting and provide assistance in designing applying AI software, and the ability to cooperate with AI engineers. This competency model will not only promote the development of AI technology in the industrial design trade by imposing new demands on industrial designers but also point out the direction for the cultivation of design talents in institutions of higher learning.

*Keywords:* Artificial intelligence, industrial designer, competency model, design education.

### INTRODUCTION

As artificial intelligence (AI) technology being applied in-depth in a variety of fields, it will greatly change our lives in the foreseeable future, as a result of which a number of policies have been issued successively by state and local governments of China to promote AI to a national strategic level while many experts and scholars are successively involved in the research and discussion on the AI technology from the perspective of their own disciplines. Although the industrial design field is characterized by innovation as one of its strengths, an extensive range of AI design software has already become popular in the market quietly. Examples are the software name Banner which is able to accomplish the design of 8,000 posters within a second, the software ARKie and Adobe Sensei capable of quick design of all variety of posters, Tailor Brands, and Logojoy, which are able to design various logos within 1.5 seconds, and the software name of AutoDraw and Prisma which make it possible for a new hand of painting to become a master of art in a minute; More examples are Philippe Starck who designed the first AI seat using AI software in 2019 and Designer Philip Schmitt who designed the first seat with soul by applying generative adversarial networks (GAN). In the face of the in-depth application of AI in the design field, the question is whether designers will be replaced by a machine in the future, what industrial designers need to be capable of in order to deal with this occupational crisis, and what institutions of higher learning should do to reform their design education in order to cultivate students adaptive to the new wave of technology.

Based on the competency factors of industrial designers figured out through literature research, the preliminary construction and revision of designer competency model have been accomplished through expert survey, and then the effectiveness of this model was verified by way of a questionnaire survey of designers and data analysis in this dissertation, and then built up the industrial competencies model under AI Technology. This competency model not only impose new requirements for the competence of designers, but also it divides the professional level of industrial designers in a scientific way, which points out the direction for the cultivation of industrial design talents of higher education while providing significant theoretical support for the establishment of a professional qualification evaluation system for industrial designers.

### REVIEW OF RELEVANT RESEARCH

#### Research on the Competency of Industrial Designer

As proposed by David McClelland from Harvard University in 1973, the concept of competency refers to the comprehensive competence of knowledge, motivation, self-image, characteristics, skill, and social role (McClelland & Boyatzis, 1980), which

was then divided into three dimensions including occupation, behavior, and strategic integration which respectively represent the skills to deal with specific and routine tasks, the skills to deal with non-specific and random tasks, and the management skills in the organizational situation (Marrelli, 1998).

An investigation of the industrial design graduates from the University of Canberra in Australia in 1998 showed that the elements for survival in an enterprise include ten skills such as hand painting, model construction, drawing software, expression ability, etc. (Liu Tao, 2006). In 1999, a research was conducted by the Industrial Design Department of Japan concluding the competence requirements of designers and the weight as shown below: planning capability (0.3), modeling ability (0.25), thinking (0.2), coordination (0.12), expression (0.08) and computer operation (0.05). Researcher (Xiao, 2006) divided the basic competence of an industrial designer into six capabilities, including thinking, connection in mind, analysis, problem-solving, observation, and practice. Yan (2009) believed that a professional designer must have the capability to identify and solve problems, innovation ability, and teamwork. Researcher Hu and Zhao (2009) analyzed the competence an industrial design talent should have from three aspects, including education in institutions of higher learning, design contests, and business market, and proposes 13 points for evaluation. Lecler and Horan (2018), by deeply exploring the core competence and psychological features of designers, concluded that creativity, exploration, and initiative are gatekeepers of designers' abilities.

In summary, the competency of industrial designers refers to the knowledge, skills, values, appreciation ability, and creativity as necessary to successfully accomplish design tasks, and an industrial designer is required to not only have the professional ability to deal with specific, routine tasks, and the behavioral ability to deal with non-specific, random tasks, but also have the management capability to deal with the organizational situation.

### **Research on the Competence Model of Industrial Designer**

Chen (2011), thorough investigation on the competence and quality features of creative talents, summarized five level-1 indexes including knowledge, personality traits, motivation, innovation, and general ability, as well as 20 level-2 indexes. Duan (2011) divided the competence of industrial design talents into three level-1 abilities, including basic public knowledge, specialty, and innovation, as well as five level-2 abilities. The researcher McLaughlin proposed the competence iceberg model dividing competency features into five categories: knowledge, traits, motives, self-concept, and skill, which reflected the hidden potential motivation and characteristics of ability (McLaughlin et al., 2012). Duan (2012) thought that innovation, professionalism, analytical thinking, communication skills, customer awareness, and market analysis should be included in the competency model of industrial designers. Cao (2013) deduced a competence structure model of industrial designers by applying the component sub-theory of competence to conclude three level-1 abilities, ten level-2 abilities, and 16 level-3 abilities, and identifies the weight of evaluation indexes for the competence of senior, middle-level, and junior industrial designers. Nieminen (2015) used the quantitative analysis of questionnaire and model validation to construct a user-centered designer competence model based on 12 abilities of designers such as user advantage, soft skill, hard skill, designer advantage, etc. Lee (2016) developed an evaluation scale for the industrial design ability index (IDAI) through quality function deployment (QFD) and grey relation analysis (GRA) and then verified the effectiveness of the evaluation scale by testing 211 university students. Moreover, Bi, Wang, and Liu (2018) constructed a design competence evaluation system under the cloud manufacturing mode from perspectives of meta-competency and the competency on industry technology, design tasks, and learning ability.

### **New Competence Demands Imposed by AI Technology**

With the continuous penetration of AI technology in the field of design, some scholars have begun to think about the demands for the competence of designers. For example, Yang (2018) pointed out that in the era of AI, designers were required to have the ability to integrate interdisciplinary knowledge, reserve cross-domain knowledge, and transform the design direction from functionality into emotional beauty. Another example is Ning Fang, who believed that industrial design was moving towards a more complex inter-discipline and that industrial design talents should have a higher ability of innovation by integrating professional knowledge and the ability to deliver innovative design with the help of a network (Ning, 2018). Moreover, the researcher Zhang (2020) conducted an investigation on the necessity and feasibility of AI basic education for the development of design discipline and design education, and a discussion on the potential risks incurred due to AI education in design and their coping strategies.

Looking back to the existing literature, it's not difficult to find that current researches on the competency model of industrial designers are characterized by the following: firstly, while the researches on competency are relatively mature both at home and abroad, the researches on competency model specific to industrial designers are low in number and the theory not systematic enough. Secondly, the division of competency factors of industrial designers is ambiguous, lacking scientific criteria for selection and evaluation. Thirdly, the researches on the evaluation of abilities of industrial designers are mainly focusing on the composition of competency factors rather than the analysis of the weight of each factor. Fourthly, the impact of new technology on the ability of industrial designers was not taken into consideration. As a consequence, this research is innovative by systematically sorting out the competence structure of industrial designers using scientific, statistical methods and by constructing a systematic theoretical system for the competence structure of industrial designers on the basis of AI technology.

## PRELIMINARY CONSTRUCTION OF COMPETENCY MODEL

The selection of competency factors is critical to ensure the authenticity and effectiveness of the entire competency model and that whether the selected index and the design of its weight are scientific will have a direct influence on the reliability and validity of the evaluation result of the competence model. This section selected the competency factors of industrial designers by summarizing the competency factors and their frequency present in the existing researches and combined the new demands for the competence of designers under AI technology. Then, this research revised the model based on the results from the questionnaire and interviews with experts.

### Selection of Competency Factors and Frequency Statistics

With the keywords of “industrial designer & competency” and “artificial intelligence & competence of industrial designers,” 20 papers with citation times high than ten times were selected from CNKI. Based on an in-depth study, the competency factors of industrial designers were figured out. Due to differences in the expression of competency factors of industrial designers, these statistics combined and reorganized the competency factors appropriately.

Since the existing AI software has participated in product design and preliminary research which can sort out design data, product modeling, evaluation of the functional structure, and production of renderings, industrial designers under the background of AI are required to have the background knowledge of AI, abilities of interdisciplinary integration, the abilities of data statistics and research using AI software, and even the capability of programming to guide the design of AI software. A preliminary model and specific content of competency factors for industrial designers were formed, as shown in Table 1 below.

Table 1 Preliminary model and specific content of competency factors for industrial designers under the background of AI

Level-1 Competency Factor	Level-2 Competency Factor	Specific Content
A Knowledge	A1 General Education Knowledge	With linguistic, mathematical, literary and artistic, historical and cultural ability and the ability of social analysis and moral thought and other capabilities
	A2 Professional Industrial Design Knowledge	Master basic and professional knowledge on industrial design
	A3 Humanistic Knowledge and Literacy	Possess humanistic knowledge, attitude and spirit, and the ability for penetration of culture and art to science and technology
	*A4 Interdisciplinary Knowledge	Able to integrate interdisciplinary knowledge and the reserve of cross-domain knowledge
	*A5 Background Knowledge of AI	Master the basic background knowledge of AI and big data
	*A6 Lifelong Growth Oriented Knowledge Structure	The ability to acquire and supplement new knowledge by self-study to meet the needs of social development and work
B Professional Capability	B1 Design Research Ability	Able to access, process and express design information
	B2 Design Expression Ability	The ability of design expression including expression by hand painting, plane and 3D software
	B3 Professional Aesthetic Ability	Master aesthetic principles and understand others' aesthetic views
	B4 Product Comprehensive Design Ability	Able to provide solutions to the issues existing in the appearance, function and structure of products
	B5 Ability of Teamwork, Project Planning and Management	Able to communicate with team members, make a reasonable schedule, organize personnel, allocate property and solve the problems encountered in the process of design
C Innovation	C1 Innovation of Design Thinking	The ability to creative thinking and transform from functionality into emotional beauty
	C2 Innovation of Design Methods	Able to mobilize resources to optimize allocation
*D Ability to Apply AI Technology	*D1 Ability to Apply AI Design Software	Master more than one AI design software, and provide quick assistance for the design process by computer aided engineering and reinforcement learning
	*D2 Ability to Sort Out Information with AI	Master more than one AI information process software to improve design efficiency
	*D3 Combination of Designers with Machine Trainers	Able to master an AI programming language, design data model and algorithm to guide the machine how to design (teach the machine how to design)

Note: \*The competence factors of designers under the background of AI as proposed by the author

### Expert Survey and Revision of the Model

In order to improve the scientific nature of the competency model for industrial designers under AI technology, the questionnaire and interview were used in this section to obtain expert reliability and revise the model.

**Design of Questionnaire and Selection of Experts**

The questionnaire used for the expert survey was designed to list the competency factors and the specific content. In the questionnaire, scoring criteria were divided into three levels, 3 points for appropriate one, 2 points for appropriate after revision, and 1 point for inappropriate, the last of which should be accompanied by recommended modifications. For the purpose of the survey, 15 experts were selected, 9 of which were professors engaged in design education for a number of years in universities, 4 were designers from well-known design companies with more than ten years of experience in design, and the remaining were experts with experience in AI technology. This survey includes not only a questionnaire to be completed but also a one-on-one interview to acquire more comments from experts on the revision.

**Analysis of the Survey Result**

A data model was used to analyze the survey result with the help of Mean, Standard Deviation (SD), and Coefficient of Variability (CV), wherein Mean was used for determining the concentration of experts’ opinions on a competency factor while the latter two are used for identifying the discreteness of experts’ recognition to a competency factor and to the description of behavioral features.

Known: and,  $x_i$  and  $y_i$  presents a single sample and represents a set of samples. The formula is as follows:

Mean: Represents a concentrated trend of a random variable or set of data:

$$\text{mean}_x = \frac{\sum_{i=1}^n x_i}{n} ; \tag{1}$$

SD: The degree of discreteness when measuring random variables or a set of data is absolute difference quantity:

$$D1_x = \frac{\sum_{i=1}^n (x_i - \text{mean}_x)^2}{n} ; \tag{2}$$

CV: A measure of the degree of dispersion of a group of data, belonging to the number of relative differences (difference variance):

$$SD1_x = \sqrt{D1_x}; \tag{3}$$

If CV lower than 0.15 refers to balanced data distribution and CV higher than that refers to significantly unbalanced data distribution. Table 2 shows the analysis of results from the Level-1 factor. Moreover, the experts’ comments on the revision are shown in detail in Table 3 below as supplementary to the factor.

Table 2 The analysis of the result from Level-1 factors

	CV	Mean	SD		CV	Mean	SD
A	0.23	2.77	0.62	B	0.24	2.72	0.65
C	0.20	2.80	0.55	D	0.41	2.45	0.97

From Table 2, the mean of 2.77, 2.72, 2.80, and 2.45 and the CV of 0.23, 0.24, 0.20, and 0.41, which respectively corresponds to A- knowledge, B-professional Capability, C-innovation, and D-Application of AI Technology. It can be seen that experts had a high degree of recognition in innovation, knowledge, and professional capability, instead of the application of AI technology, to which they hold different views. With regard to the AI technology factor, the Mean is 1.52 for the nine professors from universities, 2.83 for the four designers, and 3 for experts with experience in AI technology, which shows that professors from universities had Low recognition of AI technology.

Table 3 The analysis of the result from Level-2 factors

	CV	Mean	SD	Recommended modifications
A1	0.26	2.73	0.704	A5 should be modified as having the background knowledge and partial professional basic knowledge on AI
A2	0.18	2.87	0.516	
A3	0.18	2.87	0.516	
A4	0.27	2.67	0.724	
A5	0.28	2.60	0.737	
A6	0.18	2.87	0.516	
B1	0.28	2.60	0.737	None
B2	0.20	2.80	0.561	

B3	0.28	2.60	0.737	
B4	0.18	2.87	0.516	
B5	0.26	2.73	0.704	
C1	0.18	2.87	0.516	None
C1	0.18	2.87	0.516	
D1	0.42	2.33	0.976	D1 should be modified as the ability to know about AI software D3 should be modified as the collaboration between designers and AI engineers
D2	0.22	2.73	0.594	
D3	0.59	2.29	1.356	

From Table 3, Among the six level-2 competency factors under A-knowledge, the recognition of A2- professional knowledge on industrial design, A3- humanistic knowledge, and A6-lifelong growth-oriented knowledge structure were high, while that A5-background knowledge of AI was lower. In the opinion form experts, the background knowledge of AI is wide and difficult, so it is difficult for students to master it. The students can understand the basic knowledge and application of artificial intelligence than master the knowledge.

Among the five level-2 competency factors under B-professional capability, the recognition to each competency factor was high, and B2-design expression ability and B4-product comprehensive design ability were highest.

Among the two level-2 competency factors under C-innovation, C1-innovation of design thinking and C2-innovation of design methods had higher value of Mean, showing that experts were unanimous, shared a high degree of recognition and believed the importance for industrial designers to have innovative thinking and ability under the background of AI.

In terms of D-Ability to apply AI technology, the value of Mean of D1- ability to apply AI design software, D2- ability to sort out information with AI, and D3- a combination of designers with machine trainers were 2.33, 2.73, and 2.29, and the CV of them is 0.42, 0.22 and 0.59 respectively. The experts had more different opinions and discussed lots in this section. The experts recommend that the degree of mastery D1 should be modified from application to understanding. And they believed it was quite high demanding for designers to master an AI programming language, and the D3 should be revised as the collaboration between designers and AI engineers.

## VERIFICATION OF THE COMPETENCE MODEL

### Design and Distribution of Questionnaire

Based on the feedback of the experts on the competency model, another questionnaire was formulated, and verification was conducted by having more designers complete it. A five-point scale was used in the questionnaire where options and respective scoring were shown as follows: highly inconsistent (1 point), inconsistent (2 points), moderate (3 points), consistent (4 points), and highly consistent (5 points). The questionnaire was distributed online via www.wjx.cn. The questionnaire sent out 180 and 156 effective, which the effective rate was 86.7%. The survey subject consists of a young population aged from 18 to 25 making up 83.3%, a group aged from 26 to 30 occupying 7.7% and the rest aged from 31 to 40 accounting for 8.3%, of which people with working experience in design up to 1-3 years take up 31.4%, and more than three years design experience proportion was 11.5%.

### Analysis and Test of Questionnaire Results

The questionnaire analysis not only used the Mean, which formula is (1) but also added the reliability test, which can reflect the reliability of the questionnaire. The reliability test refers to the degree of consistency of the results obtained by repeated measurement of the same research object using the same method. This article used Corrected Item -Total Correlation (CITC) and Cronbach's  $\alpha$  :

CITC: Corrected item-total Correlation, It is generally represented by the letter r, which is used to measure the linear relationship between two variables:

$$r(X, Y) = \frac{\text{Cov}(X, Y)}{\sqrt{D1_X * D1_Y}}; \quad (4)$$

Cronbach's  $\alpha$  : it refers to the average value of the split-half reliability coefficient obtained by all possible item division methods of the scale:

$$\alpha = \frac{K}{K-1} \left( 1 - \frac{\sum_{i=1}^K D_{C_i}^2}{D_C^2} \right) \quad (5)$$

$C = \{c_1, c_2, \dots, c_k\}$ ,  $C_i = \{c_{i1}, c_{i2}, \dots, c_{im}\}$  K is the number of items on a scale, is the variance of the total sample, is the variance of the observed sample.

The analysis and test of questionnaire results are shown as Table 4. The relation of the mean of each level-2 competency factor as shown as Figure 1.

Table 4 The analysis of results from the questionnaire survey

L1	L2	Mean	CITC	$\alpha$
A Mean= 3.58	A1	3.74	.653**	.929
	A2	3.83	.863**	.924
	A3	3.58	.551**	.931
	A4	3.44	.678**	.928
	A5	3.23	.575**	.930
	A6	3.64	.715**	.927
B Mean= 3.90	B1	3.95	.813**	.926
	B2	3.92	.642**	.929
	B3	4.07	.654**	.929
	B4	3.82	.767**	.927
	B5	3.90	.709**	.928
C Mean= 3.85	C1	3.88	.754**	.927
	C2	3.81	.607**	.930
D Mean= 3.31	D1	3.34	.485**	.934
	D2	3.29	.698**	.927
	D3	3.29	.579**	.932

Note: \*\*significant correlation at 0.01 (bilateral), \*significant correlation at 0.05 (bilateral); it is required for CITC>0.400, and Cronbach  $\alpha$ =0.933

From Table 4, analysis was performed to study the correlation between each item and dimensions, the strength of which was represented by the Pearson correlation coefficient. From table 4, it can be seen that there was a significant positive correlation between each item from A1 to A6 and the knowledge dimension (A), of which the positive correlation between A2-professional knowledge on industrial design and the knowledge dimension (A) was most significant. The same situation occurred when it comes to each item from B1 to B5 and the professional capability (B), between C1, C2 and the innovation (C), and between each item from D1 to D3 and the ability to apply AI technology (D). In each case, a significant positive correlation existed between them, and the most significant one occurs respectively between B1- design research ability and the professional capability (B), between C2- innovation of design methods and the innovation (C), and between D2- the ability to sort out information with AI software and the ability to apply AI technology (D).

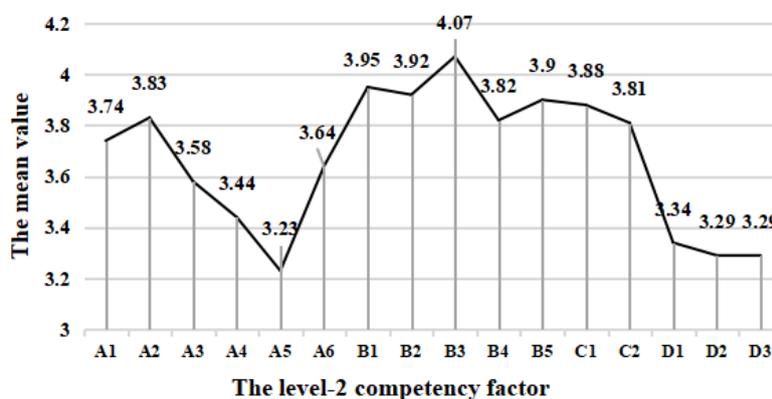


Figure 1: The relation of the mean of each level-2 competency factor

Reliability analysis was used to study the accuracy of quantitative data, in which generally the correction item-total correlation (CITC) higher than 0.400 is desirable, and Cronbach's  $\alpha$  exceeding 0.8 represents high reliability, from 0.7 to 0.8 is good reliability, from 0.6 to 0.7 is acceptable reliability, and if less than 0.6 is poor reliability. Where the value of Cronbach's  $\alpha$  if

the item is significantly higher than Cronbach's  $\alpha$ , then re-analysis upon deletion of the item may be considered. As we see from Table 4, the reliability coefficient is 0.933, higher than 0.9, demonstrating high reliability of the survey data. In accordance with the "Cronbach's  $\alpha$  if item deleted," the reliability coefficient will increase significantly if D1- ability to apply AI design software is deleted. As a result, this item may be revised or deleted. The CITC of all items as analyzed is higher than 0.4, which not only showed that there was a good correlation among them but also demonstrated sound reliability.

### Revised Competency Model of Industrial Designers under AI Technology

Based on experts' comments and the result from the questionnaire survey of designers, for the purpose of the A- knowledge dimension, the modification was made to A5- background knowledge of AI and big data of which mastering was revised as understanding with reference to experts' comments. For the purpose of C- innovation, a high degree of recognition fell on this part as concluded from both the expert interview and the questionnaire survey of designers. Therefore it remained unchanged. In terms of D-ability to apply AI technology, an expert discussion was concentrated on D1-ability to apply AI design software which, as recommended, should be modified as the ability to know about AI design software, as well as D3- a combination of designers with machine trainers for which they believe that it is quite demanding for designers to master an AI programming language and that it is necessary to strengthen the collaboration between designers and AI engineers. Given the above, the competency model of industrial designers under the background of AI was finalized, as shown in Figure 2.

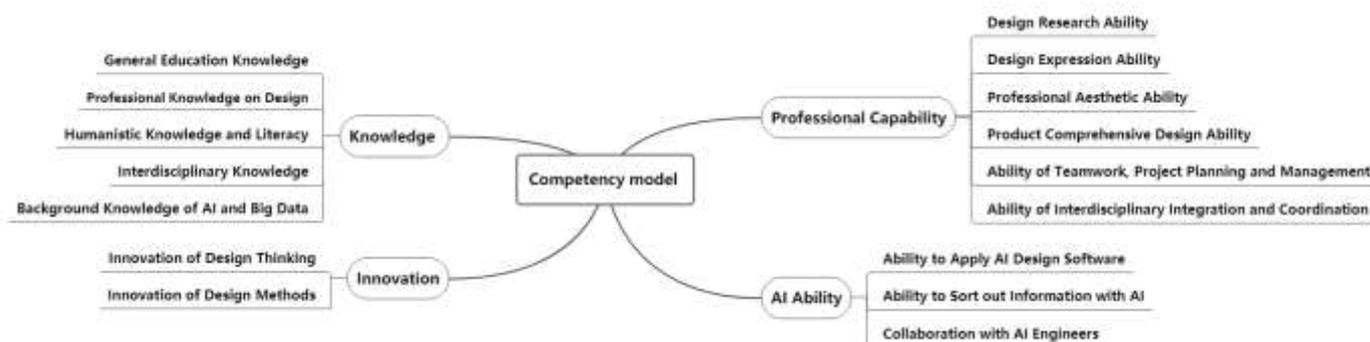


Figure 2: Competency model of industrial designers under the background of AI

### CONCLUSION

As AI technology is altering with each passing day, the influence in AI education is changing accordingly. AI applications emerge in an endless stream, and each of them has differed a lot from others. For the purpose of design, industrial designers need to take on a series of processes including preliminary survey, data analysis, sketch design, computer modeling, and post-processing of scheme, of which many a process is tedious and inefficient, taking a very long time to complete and requiring designers to repeat a piece of simple work for a long-term, such as a preliminary survey that needs a lot of time to access to and sort out information, and post-processing of scheme that requires designers to adjust all parameters through a computer. However, by completing the preliminary data sorting and production of renderings with high efficiency, the AI information processing software and design software will help designers save most of their time, and thus making it possible for designers to spare more time to do innovative design.

In order to keep up with the development of artificial intelligence technology, designers should not only have the basic design professional ability and design professional knowledge, but also have the ability of interdisciplinary integration and coordination, the knowledge structure of interdisciplinary and lifelong growth, the basic knowledge of artificial intelligence and big data background, and the ability to use artificial intelligence software to assist design information collation and improve the design process. At the same time, higher-level designers need to be able to master AI programming language, design data models and algorithms to guide the machine on how to design. So it is necessary to update the demands for the competency of a designer in real-time with the development of AI technology.

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## Study on the Influencing Factors of Health Information Sharing Behavior of the Elderly under the Background of Normalization of Pandemic Situation

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### ABSTRACT

This study aims to solve the problem of unwise judgment, decisions, and correspondingly dangerous behaviors caused by error health information to the elderly. Based on the MOA model and self-determination theory, this paper constructs a health information sharing model for the elderly and analyzes it with Amos's structural equation model. The study finds that media richness, health information literacy, perceived benefits, and negative emotions of the coronavirus epidemic positively influence health information sharing behavior. In contrast, perceived risks have a significant negative impact on health information sharing behavior. At the same time, media richness positively affects health information literacy, perceived benefits, and negative emotions of the coronavirus epidemic but has no significant impact on perceived risks. Health literacy positively affects perceived benefits but does not significantly affect the perceived risks and negative emotions of the coronavirus epidemic. This study aims to assist government and online social platforms in taking relevant measures under the background of normalization of the pandemic situation, controlling the spread of error health information among the elderly, and guiding the elderly to share health information better.

*Keywords:* Pandemic situation, the elderly, information sharing, health information, MOA theoretical model, self-determination theory.

### INTRODUCTION

These years have witnessed the aging population of China continues to deepen. By November 2020, China's elderly population aged 60 and above has reached 264 million, accounting for 18.7% of China's total population, and its proportion has increased by 5.44 percentage points. The international and domestic COVID-19 are repeated constantly, in which case epidemic prevention and control should be regarded as a standard management model. After the outbreak of COVID-19, many aged people began to contact with mobile intelligent devices to meet the epidemic prevention and control requirements more conveniently in daily life (for example, using Health Codes). In this case, a growing number of aged people have become netizens gradually. Exposed to news, articles, and other forms of health information related to the epidemic situation through the Internet, aged people tend to comment and forward through online social platforms.

Under the pandemic situation, aged people pay more attention to health, collecting health information frequently (Pálsdóttir 2011). Sharing health information has become a crucial way to gain a sense of value and vent their emotions (Wasko *et al.*, 2005). However, due to the lack of health information literacy of the aged, they can hardly distinguish error health information on the Internet, such as non-authoritative health advertisements and health rumors that spread false information under the guise of science or authority. Not only will it impede the epidemic prevention work of the aged who are susceptible population in COVID-19, but it also will reduce the vigilance of the elderly in epidemic prevention and become a substantial hidden danger in epidemic prevention work.

Therefore, in the case of the normalization of the COVID-19 pandemic, exploring the influencing factors and mechanisms of the elderly's health information sharing behavior on the Internet will help the aged reduce the risk of encountering "false health information" on the Internet when such public health emergencies occur, reducing the negative impact of health information and the phenomenon of false health information dissemination caused by improper health information sharing behavior of the elderly.

Correspondingly, it will promote the aged in China to share and exchange health information correctly when public health emergencies occur, improve their health information literacy and form a correct health awareness.

In this study, the formation mechanism of self-determination behavior of elderly people's health information sharing will be discussed theoretically by combining MOA theoretical model and self-determination theory. Combined with the questionnaire survey results, the structural equation model of data will be used to analyze the path of various factors affecting elderly people's health information sharing behavior. Based on this idea, some countermeasures and suggestions are used to guide elderly people to share high-quality health information. Specific research questions include: What factors affect the health information sharing behavior of the elderly under the background of normalization of pandemic situations? What are the factors that promote and hinder the elderly's health information sharing behavior? How do these factors affect the health information sharing behavior of the elderly? What is the influence mechanism?

Combined with the questionnaire survey results, the structural equation model of data will be used to analyze the path of various factors affecting elderly people's health information sharing behavior. By analyzing the data, we found that media richness, health information literacy, perceived benefits, and negative emotions of the epidemic situation all positively impact health information sharing behavior. At the same time, media richness positively affects health information literacy, perceived benefits, and epidemic negative emotions but has no significant impact on perceived risks. Health literacy positively affects perceived benefits but has no significant effect on the epidemic situation's perceived risks and negative emotions. In contrast, perceived risks have a significant negative impact on health information sharing behavior.

The study concluded that social media managers should take the initiative to assume social responsibility in an epidemic, strengthen the review and supervision of online health information, create a positive anti-epidemic atmosphere and accurately push some authoritative health information to the elderly in an epidemic. Based on this idea, countermeasures and suggestions are put forward to guide the elderly to share high-quality health information from the perspective of policymakers and media managers. Government departments should accurately grasp the emotional changes of the elderly in the case of an epidemic and quickly provide targeted and rapid reassurance and value guidance.

The remainder of the paper is organized as follows. Section 2 reviews the previous articles and theories about health information behavior and introduces the research scenarios of the MOA theoretical model and self-determination theory in information behavior. Section 3 describes the research methods to explore the influencing factors of health information sharing behavior of the elderly, including the construction of health information sharing behavior of the elderly model and the process of empirical research. Section 4 presents the running results of the study model, and the results are discussed in Section 5. Section 6 summarizes all the work of the study.

## LITERATURE REVIEW

Manafa and Wong believe that health information behavior refers to a series of behaviors generated in people searching, screening, and selecting health information in an event or situation (Manafa *et al.*, 2012). In the past, the research on health information behavior at home and abroad mainly focused on health information search behavior (Beaudoin *et al.*, 2011). With the development of social media platforms such as the health community and WeChat, people's health information sharing behavior has increased. Therefore, health information sharing behavior has gradually attracted the attention of scholars at home and abroad (Yan *et al.*, 2016). Scholars mainly study the influencing factors of information sharing behavior from different situations and information sharing subjects. For different situations, most studies focus on learning, health, and other situations, but few studies are set in public health emergencies. The influence mechanism of user group differences or internal determinants of information behavior is studied for the research subjects. However, few studies focus on the particular group of the elderly.

With the growth of age, the physical function and cognitive level of the elderly gradually decline, and they are a particular group "marginalized" in the network social environment. Every process of the elderly's information behavior depends on their existing knowledge structure and cognitive ability (Sutcliffe *et al.*, 1998). Therefore, the elderly's health information literacy, the knowledge structure and judgment ability of health information, is an essential factor affecting the elderly's health information behavior. In addition, the emotional and psychological factors of the elderly affected by their health status and social health information are also the main factors affecting their health information behavior (Miles *et al.*, 2008; Nelissen *et al.*, 2015). In addition to the help of relatives, social support factors such as media richness and the judgment of interpersonal benefits and risks caused by this behavior are the main factors affecting the health information behavior of the elderly (Eastin *et al.*, 2005).

In the research context of health information sharing behavior of the elderly, their health information behavior refers to a series of behaviors produced in the process of searching, screening, and selecting health information in an event or situation (Manafa *et al.*, 2012). Information sharing is a dimension of information use, which refers to how an individual obtains information and then transmits it to another person (Erdelez, 2000). According to the theory of media richness, this paper defines media richness as the ability of how much information the media can spread and the quality and effect of the information content (Chen *et al.*, 2004). Some studies have applied platform factors such as media environment to the research of information behavior and believe that the stimulation of media environment will affect users' information behavior. The American Academy of medical research (IOM) defines health literacy as "health literacy refers to an individual's ability to obtain, process and understand basic health information and services to make appropriate health decisions" (Fu *et al.*, 2017; Suri *et al.*, 2016). Health literacy includes the

knowledge level and ability level. The ability level is health information literacy, which is the core of health literacy. Because elderly people are susceptible to the new crown virus, their emotions are easily affected by the epidemic-related health information on the Internet. Some studies have shown that emotion, as a motivation, can stimulate users' information-sharing behavior (Wellman *et al.*, 1996). In the epidemic environment, the elderly vent the negative emotions caused by the epidemic and carry out information-sharing behavior.

In information behavior research, MOA model theory and self-determination theory have been successfully used to explain a series of user information behaviors. MOA model, namely the motivation opportunity ability model, was first proposed by MacInnis and Jaworski (MacInnis *et al.*, 1991). Recently, MOA theory has been used to explain the influencing factors of information sharing behavior. For example, the Song Xiaokang and Zhao Yuxiang take health rumor sharing behavior as the function of MOA influencing factors and take motivation opportunity ability as the starting point to explain the main influencing factors of health rumor sharing behavior from the three dimensions of motivation opportunity ability (Song *et al.*, 2020). In the MOA model, motivation, opportunity, and ability are interrelated. When individuals have these three simultaneously in the online social platform, the higher the probability of information sharing. Self-determination theory is a motivational process theory about human self-determination behavior proposed by Deci *et al.* (1985). Its core elements are internal motivation and external motivation. In recent years, self-determination theory has been gradually applied to the research situation of information sharing. For example, Chang Victor, Sun Siwei, and others explored the interaction between researchers' knowledge-sharing incentives in online multi background communities based on self-determination theory (Sun *et al.*, 2021).

## METHODS

### Study Model

This study takes the elderly as the research group. Under the specific social health background of epidemic normalization, this study aims at health information and analyzes the influencing factors of information sharing behavior of the elderly. MOA model can analyze the influence mechanism of various factors affecting the health information sharing behavior of the elderly on the actual behavior under the framework of motivation opportunity ability. Combined with self-determination theory, we can further explore the formation mechanism of ability and opportunity factors on internal motivation and external motivation to further analyze the influence path of health information sharing behavior. Then we can explore the methods to guide the elderly to share health information correctly under the thinking logic of mutual transformation of internal and external motivation.

Motivation is the main factor that determines users' behavior of information sharing (Lu *et al.*, 2012; Lin & H.F., 2007a, 2007b). In the MOA model, motivation is a kind of motivation to guide individuals to produce specific behaviors, which can generally be expressed by willingness, interest, and desire to process information. According to self-determination theory, motivation is divided into external motivation and internal motivation. In the research of information sharing, the external motivation is mainly related to users' perceived value, that is, the comparison between the costs and benefits perceived by users in the process of information exchange. The cost includes the risk cost of personal and social image loss borne by users in sharing behavior, and the potential benefits include reciprocity, improving their reputation, and so on.

Emotion plays an essential role in internal motivation. Self-determined behavior, that is, information sharing behavior has the incentive to provide energy caused by emotion and the need for future satisfaction. The social network platform is an open platform. Users can freely express their views and emotions through information sharing. As a new type of virus, COVID-19 has limited public knowledge and a large volume of outbreak information quickly, which has caused negative emotions of the elderly such as nervousness, anxiety, sadness, disappointment, fear, and worry. Van *et al.* pointed out that public emergencies are also emotional events under the epidemic situation, the demand for emotional expression of the elderly increases, and their information-sharing behavior is affected by internal motivation such as emotional release (van der Meer *et al.*, 2020). Therefore, the expression of negative emotions of the epidemic situation is taken as the main factor of their internal motivation.

According to MOA theory, ability refers to the ability and proficiency to understand and use information. In the health context, the health information literacy of the elderly is the core competence factor for health information sharing in the social network platform. Fu *et al.* believe that the knowledge and ability to meet people's health needs are critical factors for people to share health (Fu *et al.*, 2017). Nutbeam and others believe that critical thinking literacy is essential for people to analyze health information and selectively use health information critically (Nutbeam & D, 2000a, 2000b). Therefore, this study believes that health information literacy can be expressed as the ability factor in the health information sharing behavior of the elderly. Combined with self-determination theory, the ability of the elderly to complete challenging tasks will also have a specific impact on the motivation of health information sharing. Therefore, as a competency factor, health information literacy can directly affect the health information sharing behavior of the elderly and affect the development results of individual behavior by affecting personal competency motivation.

According to MOA theory, opportunity refers to the situational factors faced by individual executive behavior. When the elderly share health information on the Internet, the main environment of their behavior has changed from the traditional social environment to the network media environment such as social platforms. With the continuous development of social platforms, the public demand for information in public health emergencies increases, which means that the public use of social media has increased significantly. Moreover, social media and other platforms have accelerated the spread of false information in public health emergencies and strengthened it continuously (Qazvinian *et al.*, 2011). For example, at the beginning of the large-scale

outbreak of Ebola in West Africa in 2014, various "cure Prescriptions" were wildly forwarded via Twitter(Oyeyemi *et al.*, 2014). In 2015, the Zika epidemic broke out in central and South America. A large number of conspiracy theories and pseudoscientific ideas were spread on social media, and there were forums to encourage the public to refuse vaccination, even affecting the mainstream media (Dredze *et al.*, 2016). After the outbreak of the 2019 coronavirus epidemic (covid-19 for short), so-called "folk prescriptions" that can prevent or treat the virus, such as gargling with light saltwater, chewing garlic petals, drinking high alcohol, and taking vitamin C, have emerged on social media, resulting in relevant institutions having to occupy scarce and valuable public resources in the epidemic and set up a special rumor refutation platform.

It has been pointed out that social media may accelerate the dissemination of wrong information in public health emergencies. Some research, however, shows that social media is also a sharp tool to correct false information, which means it can use platform factors such as media environment to guide the elderly to share health information correctly (Alexander, 2014). This study believes that the index of media richness can express the opportunity factors in the health information sharing of the elderly. In addition, combined with self-determination theory, media richness and other situational factors directly affect health information sharing behavior and affect the development results of individual behavior by affecting individual autonomy motivation.

Based on the above analysis, the specific conceptual model of health information sharing behavior of the elderly is shown in Figure 1.

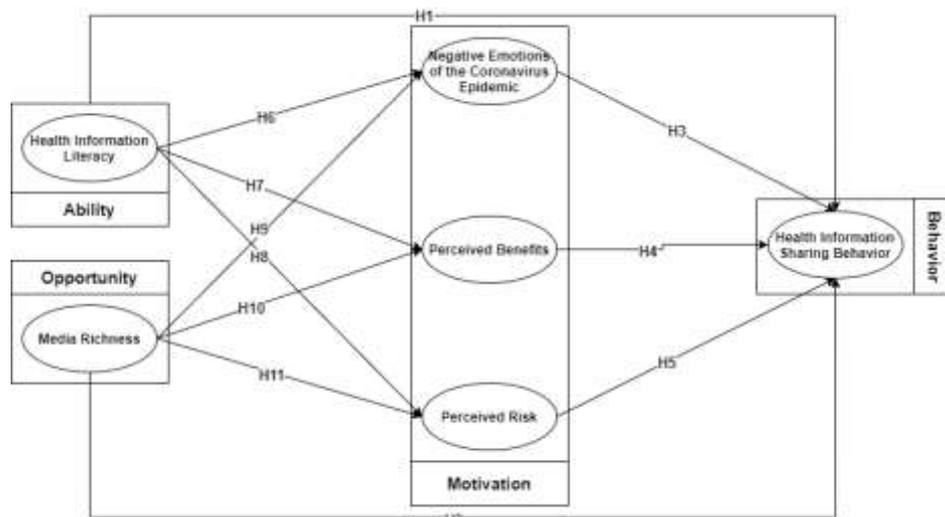


Figure 1: Conceptual model of health information sharing behavior of the elderly

## Research Hypothesis

### *Health information literacy and health information sharing behavior*

Studies have shown that user literacy (searchability, language ability, etc.) and external environmental factors directly impact information behavior, which means the health information literacy of the elderly will also affect the health information sharing behavior of the elderly (Zha *et al.*, 2014). The level of health information literacy determines whether the elderly can consciously and actively search for health information, judge it, share and use it after judgment, rather than blindly and passively accept health information from the Internet. Therefore, this study assumes that:

H1: health information literacy has a positive impact on the health information sharing behavior of the elderly.

### *Media richness and health information sharing behavior*

Some studies have pointed out that social platforms as media factors affect information sharing behavior. With the rapid development of network technology, the convenience and efficiency of information dissemination in social platforms make the "magic bullet effect" appear. The so-called magic bullet effect means that within the scope of communication, the audience will positively respond to the information, and this response will rise to the behavioral level and have consistency. In the social environment of the elderly, many friends forward health information, or friends often exchange health information. The elderly are more willing to share health information (Bock *et al.*, 2005). Therefore, the richer the health information provided by the social platform, the more types and forms, and the more people participate in information sharing, which means, the higher the richness of the media, the older people are more likely to have a positive response and have a willingness to share health information, resulting in health information sharing behavior. Therefore, this study assumes that:

H2: media richness positively affects the health information sharing behavior of the elderly.

### *Negative emotions of the coronavirus epidemic and health information sharing behavior*

Hyde's balance theory points out that when people are in a psychological imbalance, they will take various measures to restore their original balance (Heider, 2013a, 2013b). It has been considered that the health information sharing behavior of the elderly under the background of the epidemic has become a meaningful way to vent the anxiety, hypochondriasis, and other emotions of the elderly caused by the epidemic. Therefore, this study believes that with the increase of negative emotions, the elderly are

more willing to share health information related to the epidemic to vent their destructive emotions to reduce the impact of negative emotions of the epidemic. Therefore, this study assumes that:

H3: the negative emotions of the epidemic positively affect the health information sharing behavior of the elderly.

#### ***Perceived benefits and health information sharing behavior***

Perceived benefits include "for me" and "for others," and "for me" refers to the benefits brought to users by sharing behavior, such as economic or reputation benefits. "For others" refers to the benefits of sharing behavior with others (Zhang *et al.*, 2017). When the elderly can bring benefits to themselves by sharing health information, the elderly will be willing to share health information out of the need personal interests; When elderly people share health information to bring benefits to others, improve their understanding of New Coronavirus, or reduce the risk of others facing the epidemic. Under the drive of altruism demand, the elderly are also willing to share health information. Therefore, this study assumes that:

H4: perceived benefits positively affect health information sharing behavior.

#### ***Perceived risk and health information sharing behavior***

Health information often involves the privacy of users. Sharing health information always leads to privacy disclosure, which is the risk most concerned by users. The worry about a series of problems caused by privacy disclosure will make the elderly unwilling to share health information, followed by misleading others, illegal use, and other reasons (Tamjidyamcholo *et al.*, 2014). Perceived risk will bring uncertainty to users' behavior results and then inhibit users' sharing behavior. When the elderly encounter information that they think has high uncertainty, and even sharing the information will harm themselves and others, they will treat the behavior of health information sharing carefully to protect their interests from infringement. Therefore, this study assumes that:

H5: perceived risk negatively affects health information sharing behavior.

#### ***Epidemic negative emotion and health information literacy***

During the epidemic period, the health information of online social platforms is complex. At this time, the elderly are isolated at home most of the time according to epidemic prevention and control requirements. Online social platforms can help the elderly understand more health information related to the epidemic. In this case, the elderly with high health information literacy can often collect more health information related to the epidemic through the network. Swar *et al.* found through questionnaire research that perceived information overload in online health information search will aggravate users' feelings of psychological discomfort (Swar *et al.*, 2017). Gray believes that getting too much health information from the Internet can lead to health anxiety (Gray, 2018a, 2018b). The elderly exposed to too much health information cannot distinguish the authenticity of the information, or some of the information conflicts with their cognition, increasing their feelings of unknown and fear of the epidemic situation. Therefore, this study puts forward the following assumptions:

H6: health information literacy has a positive impact on the negative emotions of the epidemic.

#### ***Perceived benefits and health information literacy***

In terms of information awareness, older people tend to use smart products or services to obtain useful information to improve their own knowledge deficiency. They are relatively backward and have narrower life circles than younger people, but also have necessary information needs. On the one hand, older people with high health information literacy are more likely to recognize what information they need and then obtain and share the information that meets their needs from the Internet. On the other hand, they have the ability to judge the quality of information and then screen out information that is valuable to them. Therefore, we propose the following hypothesis.

H7: Health information literacy positively affects perceived benefits.

#### ***Health information literacy and perceived risk***

The ability to search, understand, evaluate and apply health information is the core of health information literacy. Previous studies on health information literacy mainly focused on the relationship between health information literacy and health information search behavior, library participation, health behavior, etc. few scholars studied the relationship between health information literacy and perceived risks brought by sharing health information. With the improvement of individual health literacy, individuals' perceived credibility to distorted health information gradually decreases. The higher the health information literacy, the less likely it is to believe false information. Therefore, we reasonably speculate that the higher the health information literacy of the elderly, the easier it is to perceive the risks in the process of sharing health information. Therefore, this study assumes that:

H8: health information literacy has a positive impact on the perceived risk of the elderly.

#### ***Media richness and negative emotions***

Some scholars pointed out that any public health crisis caused by public health emergencies is also an information crisis, which will produce many problems related to library and information science (Xie *et al.*, 2020). In the face of the epidemic, people generally have anxiety about whether they will be infected and whether they can be cured after infection. Therefore, people's information environment in the epidemic situation is different from that in other periods. On February 2, 2020, the global infectious disease prevention expert, Sylvie Briand, noted that the outbreak of the Infodemic also had a significant impact on people's lives. A large number of dense and difficult to distinguish true and false health information have many effects on individuals in this environment, among which information overload is one of the most common manifestations. Information

overload can cause users to have negative emotions and exaggerate their chances of developing new crown pneumonia. In addition, negative social emotions are communicable. In social interaction, individual emotions can affect others. Emotions will affect and strengthen each other and be amplified under the influence of mutual suggestion or self-suggestion.

Although the epidemic situation in the world has improved and gradually changed from large-scale to sporadic in some areas, all kinds of epidemic news in social media still touch people's sensitive nerves all the time. This study selects media richness to measure the complexity of the amount and types of information in the information environment. Explore its impact on people's negative emotions under the epidemic situation. Therefore, this study assumes that:

H9: media richness has a positive impact on the epidemic situation and negative emotions of the elderly.

#### **Media richness and perceived benefits**

By providing the richness of the information provided by the application software, users can perceive the benefits of the rich information to themselves. Users will spontaneously feel that the information is helpful to themselves or can effectively use the information. Based on this, this study believes that when the elderly get enough information from WeChat or the information provided by WeChat itself is enough, and the elderly will feel that they can benefit from it. Therefore, this study assumes:

H10: media richness has a positive impact on the perceived benefits of the elderly.

#### **Media richness and perceived risk**

In his research on consumers' perceived risk in online stores, Ye Naiyi found that the reputation of online stores and after-sales commitment of online stores can negatively affect consumers' perceived risk, which means consumers will feel less risk and avoid hesitation after contacting more information about merchants (Ye, 2008). Based on the above, when users get enough information, they can meet their expectations for information to reduce uncertainty about the unknown. Under the epidemic situation, the elderly obtain and share a large amount of and rich information through the social network platform and hope to reduce their panic about the epidemic to a certain extent. Therefore, this study assumes that:

H11: media richness negatively affects the perceived risk of the elderly.

Based on the above, the research hypotheses are summarized in Table 1 below.

Table 1: Summary of research assumptions

<b>Hypothetical content</b>	
H1	Health information literacy has a positive impact on the health information sharing behavior of the elderly
H2	Media richness positively affects the health information sharing behavior of the elderly
H3	The negative emotions of the epidemic positively affect the health information sharing behavior of the elderly
H4	Perceived benefits positively affect the health information sharing behavior of the elderly
H5	Perceived risk negatively affects the health information sharing behavior of the elderly
H6	Health information literacy positively affects the negative emotions of the elderly
H7	Health information literacy negatively affects the perceived benefits of the elderly
H8	Health information literacy is positively affecting the perceived risk of the elderly
H9	Media richness has a positive impact on the negative emotions of the elderly
H10	Media richness has a positive impact on the perceived benefits of the elderly
H11	Media richness negatively affects the perceived risk of the elderly

#### **Data Collection**

Based on literature research and existing models, this study constructs a health information sharing model for the elderly and designs a questionnaire about the maturity scale.

The questionnaire mainly includes two parts: the first part is the basic personal information, including gender, age, major, education level, the health status of the elderly, etc. The second part is the measurement of the variables involved in the study. The measurement variables include six variables: media richness, perceived risk, perceived return, health information literacy, epidemic negative emotion, and health information sharing behavior of the elderly.

In this study, the variables were measured by the Likert five-level scale, in which five options representing different degrees were set for each question item, and the respondents chose the option most in line with their cognition according to the degree of recognition.

After the preliminary questionnaire was formed, the pre-survey questionnaire was determined according to interviews with the elderly. In order to improve the accuracy and group adaptability of the questions, the study conducted a pre-survey through a small-scale questionnaire distribution and modified the questionnaire for the problems generally reflected, such as unclear significance and difficulty for the elderly to understand. The final questionnaire was obtained and officially distributed online and offline. The study used the method of young people assisting the elderly to fill in the questionnaire and finally collected 486 questionnaires. Excluding the invalid questionnaires, such as too short answer time, incomplete answers, and consistent answers, 472 valid questionnaires were obtained, and the effective rate of the questionnaire was 97.12%.

## RESULT

### Descriptive Statistics

This study mainly investigated the elderly over 55 years old who use mobile intelligent devices. Among them, men accounted for 42.58%, women accounted for 57.42%, and the proportion of men and women was relatively balanced. At the age level, the statistical results of this questionnaire show that the number of Internet users of the elderly decreases with age, which is consistent with the data results of the Research Report on Internet life of the middle-aged and the elderly issued by the Institute of Sociology of the Chinese Academy of Social Sciences in 2018.

In addition, the questionnaire also covers the elderly in different regions, educational level, age, health status, and living status, which ensures the scientificity of the research to a certain extent.

### Reliability and Validity Test

In this study, SPSS 26 was used to test the reliability and validity of the recovered formal questionnaire.

Cronbach $\alpha$  for all variables in this study and CR are more significant than 0.7, and some are even bigger than 0.8, which can be considered to have good reliability. It is generally believed that when Cronbach $\alpha$  and CR reach 0.7, the questionnaire results have passed the reliability test. In order to investigate the reliability of questionnaire measurement and the internal consistency of measurement results, Cronbach  $\alpha$  was used in this study, and Combined Reliability (CR) was used to test the reliability of the questionnaire. The results are shown in Table 2.

Table 2: Reliability test results

Variable	Title Design	Cronbach after deleting item $\alpha$	Cronbach $\alpha$	CR	AVE
MR	MR1	0.729	0.752	0.757	0.51
	MR2	0.638			
	MR3	0.621			
HIL	HIL1	0.561	0.702	0.716	0.458
	HIL2	0.641			
	HIL3	0.639			
PB	PB1	0.826	0.847	0.848	0.53
	PB2	0.825			
	PB3	0.815			
	PB4	0.819			
	PB5	0.79			
NE	NE1	0.89	0.903	0.904	0.653
	NE2	0.882			
	NE3	0.884			
	NE4	0.874			
	NE5	0.881			
PR	PR1	0.586	0.714	0.716	0.457
	PR2	0.628			
	PR3	0.659			
HSB	HSB1	0.73	0.807	0.815	0.653
	HSB2	0.765			
	HSB3	0.703			

At the same time, this study compares the correlation coefficient between variables with the quadratic root of AVE value (diagonal value), as shown in Table 3, the quadratic root of the AVE value of each variable is more significant than 0.676 and greater than the correlation coefficient between variables, so it has good aggregate validity and discriminant validity.

Table 3: Aggregate validity and discriminant validity

	MR	HIL	PB	NE	PR	HSB
MR	0.714					
HIL	0.634	0.677				
PB	0.621	0.596	0.728			
NE	0.533	0.345	0.457	0.808		
PR	-0.187	-0.176	-0.168	-0.077	0.676	

HSB	0.709	0.644	0.685	0.571	-0.34	0.771
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**Structural Equation Analysis**

**Model construction and fitting**

In order to understand the impact of media richness, perceived risk, perceived return, health information literacy, and negative emotions of the coronavirus epidemic on the health information sharing behavior of the elderly, this study used Amos 24 to draw the structural equation model of the health information sharing behavior relationship model of the elderly, as shown in Figure 2.

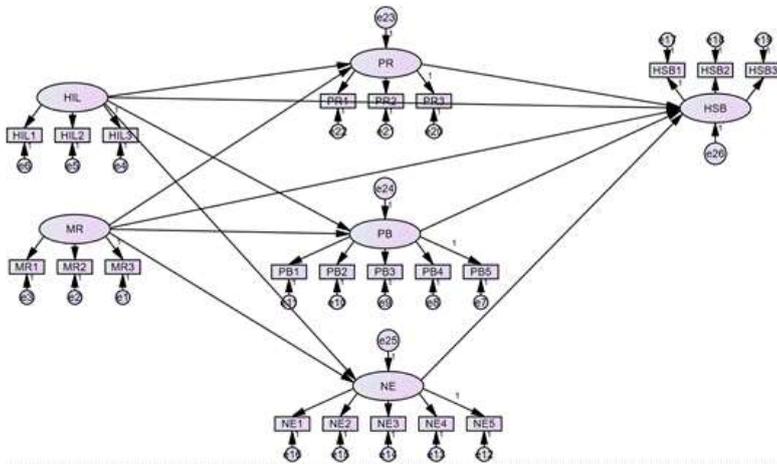


Figure 2: Structural equation model of health information sharing behavior of the elderly

The model contains six potential variables and 22 significant variables. After importing the sample data into Amos 24, the fitting degree of the model is tested in this paper. The indicators selected in this study include  $\chi^2/df$ , RMESA, RMA, GFI, AGFI, CFI, RFI, NFI, IFI, etc. It is generally believed that  $\chi^2/df$  between 1 and 3 has a good fit. When RMESA and RMA are less than 0.08, the fit is better. When GFI, AGFI, CFI, RFI, NFI, and IFI are greater than 0.9, the fit is better. If these indexes are only greater than 0.8, the model can be regarded as reasonable. The model fitting test results of this study are shown in Table 4.

Table 4: Fitting test results

Fitting index	Fitting value of this model	Recommended value	critical value
CMIN/DF	2.324	1~3	3~5
GFI	0.916	>0.9	>0.8
RFI	0.888	>0.9	>0.8
CFI	0.942	>0.9	>0.8
NFI	0.904	>0.9	>0.8
IFI	0.943	>0.9	>0.8
AGFI	0.892	>0.9	>0.8
RMESA	0.053	<0.05	<0.08
RMR	0.132	<0.05	<0.08

It can be seen that the CMIN/DF, GFI, CFI, NFI, IFI of this model have reached the recommended values, but on the whole, the fit between the model and the sample data is still poor.

**Model modification**

Because the preliminary fitting results are not ideal, this paper modifies the model based on the principle of the structural equation. Amos will give the modified index (MI) according to the fitting effect after the model operation, which researchers can use as a reference. Combined with the suggestion of model correction index (MI) in Amos and the re-review of relevant theories, the initial model is modified. Existing studies have shown that sufficient network information resources will improve users' information literacy, which means the higher the media richness, the more conducive to improving health information literacy (Qin, 2015). In confirmatory factor analysis, media richness and health information literacy also show a relatively high correlation, so a new path from media richness to health information literacy is added. The corrected fitting test results are shown in Table 5 below.

Table 5: Corrected fitting test results

Fitting index	Fitting value of this model	critical value	Recommended value
CMIN/DF	1.749	1~3	3~5

GFI	0.934	>0.9	>0.8
RFI	0.916	>0.9	>0.8
CFI	0.968	>0.9	>0.8
NFI	0.928	>0.9	>0.8
IFI	0.968	>0.9	>0.8
AGFI	0.916	>0.9	>0.8
RMSEA	0.040	<0.05	<0.08
RMR	0.058	<0.05	<0.08

By observing each fitness index in the table, it can be found that the CMIN/ DF of the research model is 1.749, which meets the standard of less than 3; The GFI value is 0.934, exceeding 0.9; The AGFI value is 0.916, exceeding 0.9; The CFI value is 0.968, exceeding 0.9; The NFI value is 0.928, exceeding 0.9; The RFI value is 0.916, exceeding 0.9; The IFI value is 0.968, exceeding 0.9; The RMSEA value is 0.040 and does not exceed 0.05. Most indicators have reached the recommended value of model fitting, so it can be considered that the overall adaptability of the modified model is good.

### Hypothesis test and path coefficient analysis

Amos further outputs the path coefficients and their significance between the modified variables. See Figure 3 and Table 6 for details.

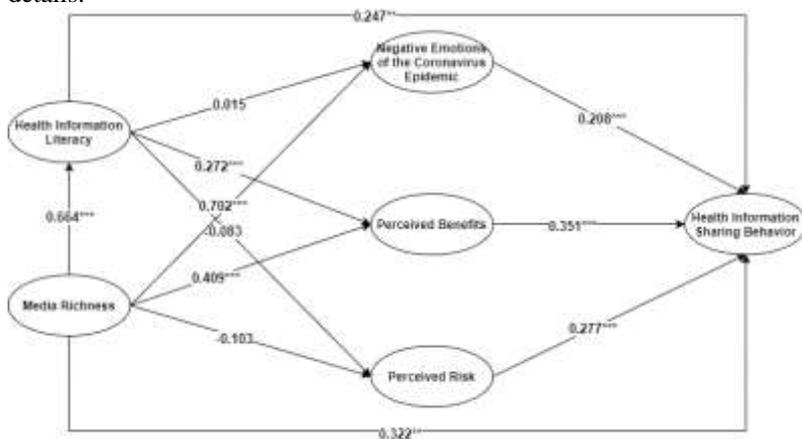


Figure 3: Simulation path coefficient diagram

Table 6: Model path coefficient and significance results

Route	Standardized regression coefficient	S.E.	C.R.	P
HIL←MR	0.664	0.076	8.735	***
PR←HIL	-0.083	0.077	-1.074	0.283
PB←HIL	0.272	0.066	4.144	***
NE←HIL	0.015	0.096	0.153	0.878
PB←MR	0.409	0.068	5.996	***
NE←MR	0.702	0.107	6.588	***
PR←MR	-0.103	0.078	-1.32	0.187
HSB←PB	0.351	0.083	4.217	***
HSB←PR	-0.277	0.066	-4.208	***
HSB←NE	0.208	0.048	4.37	***
HSB←HIL	0.247	0.08	3.086	0.002
HSB←MR	0.322	0.1	3.212	0.001

## DISCUSSION

### Discussion on empirical research results

According to the results of structural equation analysis, media richness, health information literacy, perceived income, and negative emotion of epidemic situation all have a significant positive impact on health information sharing behavior. Perceived risk has a significant negative impact on health information sharing behavior. At the same time, media richness positively impacts health information literacy, perceived income, and negative emotion of the epidemic situation, but it has no significant impact on perceived risk. Health information literacy has a positive impact on perceived benefits but has no significant impact on the epidemic's perceived risk and negative emotion.

Based on the actual situation and existing literature research, this section will first explain the above untenable assumptions and new paths and sort and analyze the variables in the established assumptions that directly affect the health information sharing behavior of the elderly according to the total effect value. Then analyze the variables that do not directly affect the health information sharing behavior of the elderly with the hypothesis is accurate, and further analyze the influencing factors and mechanism of the health information sharing behavior of the elderly.

#### ***Health information literacy and negative emotions of the coronavirus epidemic***

The health information literacy of the elderly had no significant effect on the negative emotion of the coronavirus epidemic. The elderly do not have enough information literacy, which will reduce the efficiency and effectiveness of using health information under certain conditions and cannot significantly affect their mood towards the epidemic. At the same time, the participation of elderly patients in the use of health information is also low, especially the elderly avoid mental health and resist prejudice. This will also lead to the failure of information related to improving mental health to guide the elderly during the epidemic correctly. People's long-term exposure to solid information stimulation will improve their emotional tolerance and gradually reduce their response. The elderly have received information from all aspects and all kinds of epidemic situations for a long time. No matter how much information the elderly obtains or how high the quality of information they get, their irritation to the emotions of the elderly will gradually decrease, becoming dull or numb, and show that health information literacy doesn't relate to negative emotions.

#### ***Health information literacy and perceived risk***

There is no apparent relationship between health information literacy and perceived risk. Under the background of epidemic normalization, the higher the health information literacy of the elderly does not necessarily mean that they can perceive the risks that health information sharing may have on individuals, others, and society. There is a lack of research with the same results in the field of health information, but in the research on consumers' perceived risk of online shopping by LV Wei and others, it is found that there is no significant relationship between consumers' product knowledge and perceived risk of online shopping (Jin *et al.*, 2006). This conclusion is similar to the relationship between health information literacy and perceived risk.

According to the interview results, it is inferred that there may be the following two reasons for this conclusion. First, during the epidemic, the health information in social media was too complicated and confusing. As non-professionals, especially the elderly with low health literacy, it was difficult to judge the authenticity and risk of some rumors. Second, in the late stage of the epidemic, people have a high level of risk awareness after a large number of false information and rumors during the outbreak of the epidemic. When they encounter news that cannot judge the authenticity on the social platform, they will not spread it rashly but choose to wait for the results released by the official, traditional media. Based on the two reasons above, it is not difficult to find that the status of the elderly using social media under the background of epidemic normalization is that they should be vigilant against all uncertain information, do not share it at will, and wait for official confirmation when they cannot distinguish the authenticity of health information.

#### ***Media richness and perceived risk***

There is no apparent relationship between media richness and perceived risk. This study should re-examine the existing research and theories on this hypothesis. Under the background of the epidemic situation, the network is full of a large number of negative news and even rumors, making some elderly people with poor judgment ability or low psychological quality vulnerable to negative emotions to improve the perceived risk. In other words, in the complex information interaction environment during the epidemic, the perceived risk of the elderly is affected by many factors, so the single variable of media richness has no significant impact on the perceived risk.

#### ***Media richness and health information literacy***

With the development of information technology, although some elderly people have low knowledge levels and poor learning ability, they also began to use the social network platform to receive network information gradually. Sufficient information resources provide external conditions for improving the health information literacy of the elderly so that they can use the information on the network to obtain the information they need to meet their own needs. Due to the low level of knowledge and lack of judgment, some elderly people are vulnerable to multi-angle and high-frequency radiation of network information. Some media's transfer amplification and processing guidance to factual information have compressed the information quality and richness and produced more attractive information. The elderly are vulnerable to its influence, resulting in misunderstanding and even believing in some rumors. Therefore, media richness has a positive impact on the health information literacy of the elderly.

### **Media richness and health information sharing behavior**

Media richness has a positive impact on health information sharing behavior. Media richness indirectly affects health information sharing behavior through intermediary variables such as health information literacy, perceived income, and negative emotion of the epidemic situation, but also directly affects people's information-sharing behavior. First of all, in terms of information content, health information with higher media richness has a comprehensive content coverage, which is easier to meet the practical needs of more users, and people are more willing to share such health information with their relatives and friends. Secondly, in terms of information expression, more kinds of expression methods (such as text, pictures, audio, etc.) can better meet the stimulation needs of users' different senses. Finally, in terms of information quality, users are more inclined to share high-quality information to spread knowledge or help relatives and friends, so high-quality information is always more popular. Therefore, the higher the richness of media, the more it can stimulate the health information sharing behavior of the elderly, as shown in Table 7.

Table 7: Standard total effect value of each variable on health information sharing behavior of the elderly

Variable name	Standard total effect value on sharing behavior
media richness	0.322
Health information literacy	0.247
Perceived benefits	0.351
Perceived risk	-0.277
Negative Emotions of the Coronavirus Epidemic	0.208

### **Health information literacy and health information sharing behavior**

Health information literacy has a positive impact on health information sharing behavior. The processes of information search, acquisition, and online interaction require users to have strong health information literacy. Studies have confirmed that users with high health information literacy are more willing to share health articles online (Zhao *et al.*, 2020). The elderly with high health information literacy can obtain their health information from the network and share the obtained health information. Novel coronavirus pneumonia can make full use of their abilities to identify, judge, and screen information that helps protect their health during the epidemic period and excavate some health information they believe is valuable. It can play a positive role in preventing and treating new crown pneumonia or protecting their health and health during the epidemic period and then hoping that their family members and friends will benefit from it and choose to share it. The elderly with low health information literacy have a weak ability to judge health information and cannot correctly capture valuable health information, so they will not have the behavior of sharing health.

### **Perceived benefits and health information sharing behavior**

Perceived benefits positively affect health information sharing behavior. Ybarra *et al.*'s research show that people seeking medical services seem to be using the Internet to improve their medical services (Ybarra *et al.*, 2006). They believe that using online information to diagnose problems on the Internet will make them feel more comfortable. When an act itself can benefit the actor, it makes him have a stronger willingness to complete the act. In the Internet age, the elderly, like people of other ages, can get valuable information from the Internet. When the elderly encounter information that they think is valuable, they think that it can help people effectively fight the epidemic or protect themselves, so they hope that the information can enable their family or friends to receive the information. If sharing health information makes them think that health information is irrelevant, or the information they obtain is not of sufficient value, they also lose some motivation to share health information.

### **Perceived risk and health information sharing behavior**

Perceived risk negatively affects health information sharing behavior. Some studies have shown that users pay more attention to whether the shared information harms their social communication and interpersonal relationships in using social media. Many older people expect to shape their image by sharing health information. They tend to reduce or not share the information that may affect their images, such as induced consumption, lottery, and advertising. In addition, in today's society, with the continuous postponement of the retirement age and the attention of all walks of life to mental health. At present, the elderly group still has more contact with society and is not entirely marginalized. Moreover, with the refutation of false news by major mainstream media and the publicity of "do not believe rumors, do not spread rumors" by local governments, the elderly will maintain a high awareness of information discrimination and a sense of responsibility for information dissemination. Therefore, when they encounter health information with high perceived risk or cannot distinguish its authenticity, they tend to reduce or avoid sharing such health information.

### **Negative emotions of the coronavirus epidemic and health information sharing behavior**

The negative emotion of the epidemic has a positive impact on health information sharing behavior. Under the epidemic situation, the elderly are more vulnerable to negative emotions and vent their emotions by sharing health information related to the epidemic situation. During the post epidemic period, after the blockade of the epidemic period and all aspects of social publicity, the elderly were aware of the seriousness and harmfulness of COVID-19. Their anxiety and worries about their families' health would inspire them to share more health information about COVID-19. The uncertainty of sporadic outbreaks in various places

has not been eliminated, especially with new variant crown disease strains from abroad. At present, the elderly pay more attention to physical health and daily virus protection and share relevant information with relatives and friends to jointly protect health and safety.

### ***Health information literacy and perceived benefits***

Health information literacy has a significant positive impact on perceived benefits. In using internet financial products, users will feel a series of convenience through contact processes such as platform interface design, operation process, and communication with customer service. Users' skills, including obtaining and using information, can help users explore valuable information on the Internet. People with high information literacy can judge when information is needed and know how to obtain, evaluate and effectively use the required information. Similarly, the elderly with high information literacy can identify and share information conducive to improving their social image among the many information on the Internet. On the contrary, the elderly with low information literacy does not have such ability and feel that it is more challenging to benefit them by sharing information.

### ***Media richness and negative emotions of the coronavirus epidemic***

Media richness has a positive impact on the negative emotions of the coronavirus epidemic. On the one hand, studies have found that when the information is full of fuzziness, complexity, and contradiction in the context of abundant information, uncertainty perception is usually generated (Han *et al.*, 2011). During the epidemic, the Internet was flooded with information related to New Coronavirus. The information of different forms was uneven in quality, which made the elderly unable to judge the authenticity of the information or even believe and share false information. On the other hand, if a large amount of information flows into the brain simultaneously in a short time and it is too late to be decomposed and digested, the activity of the cerebral cortex will be inhibited. Over time, there will be many negative emotions such as reduced logical thinking and judgment ability, tension, uneasiness, helplessness, etc. During the epidemic period, the Internet has become the main channel for the elderly to obtain and share health information due to home isolation. Due to their limited cognitive level and understanding ability, they are more likely to have negative emotions such as anxiety when they cannot receive relevant information beyond their limits. Based on the above, media richness will lead to the increase of negative emotions of the elderly when it increases the uncertainty perception of the elderly and makes the elderly unable to accept information fully.

### ***Media richness and perceived benefits***

Media richness has a positive impact on perceived revenue. With the development of information technology, the channels for ordinary people, including the elderly, to obtain information have gradually changed to the Internet social platform, and WeChat has become one of the Internet products used more by the elderly. Users will have a sense of commonplace after a long time of WeChat public account. This long psychological time will reduce users' interest, so users need to improve media richness by using a certain time user. Let users often find new things in the use process and increase users' interest and perceived benefits. Under the normal circumstances of the epidemic situation, the elderly have been getting health information through WeChat, TV news, and other channels for a long time. Similar to users who have used the WeChat official account for a while, they have lower interest in quality and poor health information, and lower perceived benefits. After improving the richness of media, richer health information will arouse users' interest and increase users' perceived income, so they are more willing to share health information.

### **Countermeasures and Suggestions**

With the development of information technology and the wide application of mass media during the epidemic period, information dissemination takes on new characteristics. The influx and fermentation of a large amount of information are very confusing, which increases the difficulty of screening and using health information for the elderly and intensifies the fermentation of "Infodemic." As World Health Organization director-general Tan Desai said, "we are not only fighting the epidemic, we are also fighting an 'information epidemic.'" in this context, health information sharing for the elderly.

First of all, policymakers should sense people's emotions at the first time of the epidemic, carry out rapid response guidance, and create a positive network health information environment for the elderly. In the emergency of a sudden epidemic situation, the people have an intense state of panic and fluctuation. However, the government should be prepared to understand, perceive and grasp the law of people's emotional change, and carry out targeted rapid appeasement and value guidance to drive the development of public social opinion to a positive and good situation. In creating a positive network environment, the government should make use of its advantages, fully integrate and mobilize the power of the network media platform, accurately deliver high-quality health information and authoritative information for the elderly, avoid the risk of the elderly exposed to health rumors to the greatest extent, stabilize the emotions of the elderly, and give full play to the subjective initiative of the elderly, help the elderly share more valuable health information. In addition, the government should vigorously strengthen the health information literacy education of the elderly, improve their sense of responsibility, strengthen the publicity, education, and guidance of the elderly, and improve the ability of the elderly to identify healthy information on the principle of "not spreading rumors, not believing rumors and not fabricating rumors," to make them better assume civic responsibility and jointly maintain a good atmosphere of social information dissemination.

For media managers, mainstream media should actively assume social responsibility in public health emergencies and pay attention to the authenticity and accuracy of information. In particular, the mainstream network health platform should take the initiative to make a scientific and timely response to the health problems concerned by the elderly. When accidental factors such

as public health emergencies appear, the elderly will feel powerless when digesting negative information, and the negative emotions will escalate rapidly, reducing their patience in other information. Therefore, in addition to being true, accurate, and timely, the information released by the mainstream media should also pay attention to actively responding to the focus of public attention in terms of content, and the words should be easy to understand and not easy to produce ambiguity. If necessary, simple refuted corrective information should be used instead of factual statements to achieve better health information publicity effect to create more scientific and Positive health information sharing social platform environment.

## **CONCLUSION**

### **Research Summary**

After comparing the previous literature with this paper, it can be considered that this study has the following crucial theoretical significance and practical value.

In terms of theoretical significance, this study has the following two main contributions: This paper applies MOA model theory and self-determination theory to the study of health information sharing behavior of the elderly and explores the influencing factors of health rumor sharing willingness from three aspects: individual motivation, opportunity, and ability. The motivation is further divided into internal and external motivation, and the mechanism of ability and opportunity affecting health information sharing behavior through motivation is explored, which enriches the applicable situation of the theory and expands the theoretical boundary. This study takes the epidemic negative emotion as one of the indicators of health information sharing behavior motivation for the first time. Based on Amos's structural equation, it proves that the epidemic negative emotion can significantly and positively affect health information sharing behavior. In addition, this study breaks through the traditional research index that takes time and technology cost as opportunity factors and takes media richness as an opportunity, which represents the situational factor of individual behavior, which is more in line with the actual situation of the elderly's health information sharing behavior under the condition of the epidemic situation.

From a practice perspective, the research results of this paper, to some extent, are of significance to guide the elderly to share health information correctly under the epidemic situation. First, based on the continuous and repeated social situation of COVID-19, this study analyzes the elderly's health information sharing behavior and focuses on the dual vulnerable groups under the epidemic situation and information society. In order to guide the elderly to share health information correctly and create a good network information sharing environment through related factors, To some extent, it has solid social value and practical significance to avoid the phenomenon of "pseudo health" information dissemination caused by the elderly under the epidemic situation. Second, for social media managers, this study found that media richness has a significant positive impact on health information sharing behavior, which means, the more people have access to health information in online social media, the more they tend to share health information. In addition, media richness also has a significant positive impact on health information literacy, epidemic negative emotions, perceived benefits, and other factors, indirectly affecting health information sharing behavior. Therefore, the situational factor of media richness plays an important role in the health information-sharing behavior of the elderly. Social media managers should take the initiative to assume social responsibility under the epidemic situation, accurately push some authoritative health information to the elderly, and make it easier for the elderly to access health information. On the other hand, we should also strengthen the review and supervision of network health information, create a positive anti-epidemic atmosphere under the epidemic situation, and timely control the spread of harmful health rumors. Third, for policymakers, this study found that health information literacy and negative emotions of the epidemic have a significant positive impact on health information sharing behavior, and health information literacy can indirectly affect health information sharing behavior through a positive impact on perceived benefits. In recent years, the public's concept of health has become stronger and stronger, but due to the lack of health knowledge, it is easy to be misled by health rumors. In the epidemic environment, the numerous health information makes it more difficult for the elderly to distinguish the authenticity of health information. Therefore, government departments should be prepared to understand, perceive and grasp the law of people's emotional changes, release authoritative notices and health information, and carry out targeted and rapid comfort and value guidance to drive the network information environment to a positive and sound state.

Based on the analysis above, starting from the relationship between five factors in the three dimensions of "motivation opportunity ability" of health information sharing among the elderly, the following countermeasures and suggestions are put forward to guide the elderly to share network information correctly.

### **Deficiency and Prospect**

Based on the MOA theoretical model and self-determination theory, this study explores the influencing factors and mechanism of health information sharing behavior of the elderly under the background of epidemic normalization from the three dimensions of motivation opportunity ability, expands the research in the field of information sharing behavior to a certain extent, and finally puts forward relevant countermeasures and suggestions combined with the empirical results. Considering the reliability of the questionnaire collection results, the research project members have direct or indirect guidance for the elderly to fill in the questionnaire. Besides, the requests of the research project members were rejected by many elderly people due to their strong vigilance. Therefore, the number of questionnaires collected is limited to a certain extent. In addition, the scope of the questionnaire is in China, whose situation of epidemic prevention and control is different from that in the world. Therefore, the conclusions on the influencing factors of health information sharing behavior of the elderly are lack universality in the world. In future research, we can further expand the scope of research samples, continue to explore the health information sharing behavior

of the elderly under the normalization of epidemic situations abroad, and compare it with that in China. In addition, the normalization of the epidemic situation is a duration scope, and the questionnaire collection time of this study is only a time point within the duration scope. Therefore, future research can also explore the changes in health information sharing behavior of the elderly over time through multiple empirical investigations under the condition of long-term coexistence of epidemic situations.

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## Success Factors of Chat Commerce in Thailand: An Emerging E-Business Platform in the Post COVID Era

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### ABSTRACT

In Thailand, conversation commerce or chat commerce is one of the successful E-business platforms emerging in the Post COVID era. Hence, the objective of this study is to examine six factors that may lead to the success of chat commerce. These six factors are (1) Perceived Ease of Use, (2) Perceived Usefulness, (3) Compatibility, (4) Subjective Norms, (5) Trust, and (6) Attitude towards chat commerce. It also aims to study the differences of these factors across four generations; (1) Baby Boomer, (2) Gen X, (3) Gen Y, and (4) Gen Z. The data is collected from 253 respondents via Google Forms with 182 respondents having chat commerce experiences. It is found from statistical analyses on the collected data that perceived ease of use and perceived usefulness of chat commerce receive the highest average scores from respondents from all four generations, while trust in chat commerce receives the lowest average score. Moreover, Gen Z respondents give higher average scores of all six factors than respondents from other generations. The results of this study provide us with a better understanding of why Thai people in each generation enjoy using chat commerce.

*Keywords:* Chat commerce, perceived ease of use, perceived usefulness, compatibility, subjective norms, trust, attitude.

### INTRODUCTION

“According to Darwin’s Origin of Species, it is not the most intellectual of the species that survives; it is not the strongest that survives, but the species that survives is the one that is able best to adapt and adjust to the changing environment in which it finds itself.” — Leon C. Megginson, 1963.

Lockdown and reopening policy during the pandemic of COVID-19 in Thailand cause a lot of troubles for business management. Many businesses lost their customers during the lockdowns and had to find new business strategies in order to survive. When the government eases the lockdown, some of them, however, are not ready for the reopening. The main reason is that for the reopening, businesses have to ensure the safety of the customers. Hence, at some reopened department stores in Bangkok, staff would greet customers and give them a hand sanitizing gel at the same time. Shoppers may be asked to register via a mobile app before entering the department stores, while staff must take rapid COVID-19 tests on a regular basis. Because of these many safety policies, some businesses choose an alternative way to keep in touch with their customers no matter during the lockdown or the reopening periods. One of the chosen platforms is conversation commerce or chat commerce.

### LITERATURE REVIEW

#### Chat Commerce

Chat Commerce in this research is a form of online shopping by using chat applications such as LINE or Facebook Messenger as a means of communication between sellers and customers and conducting product trading transactions. It covers the use of official business chat accounts. The concept of chat commerce is simple; the conversation has always been a part of customers’ purchases. Chat commerce has great business potential because it provides customers a safe platform for transactions and provides businesses with a natural way of online marketing. Businesses can use chat commerce for direct interaction with their customers. Moreover, chat commerce saves customers time and money, and it is easy for customers (Piyush *et al.*, 2016).

#### Chat Commerce in Thailand

The popularity of using smartphones is increasing among Thai people. Thailand is the country with the 3<sup>rd</sup> highest number of mobile internet users in the world, with almost 80% of the Thai population using social media. So, commerce through social media and smartphones becomes a great business opportunity. Online trading in Thailand has a total value of approximately 270 billion Baht (or about 8 billion USD) at present, with 62% coming from social media trading or Social Commerce and 38% coming from online marketplaces and brand websites. Since Thai people like to talk, ask, and chat on social media, chat commerce has become the present and future of doing business in Thailand. Talking and asking for trading or chat commerce is

an important trend for doing business in Thailand. LINE Thailand Head of E-commerce says that there are more than 47 million LINE users in Thailand. And LINE wants Thai entrepreneurs to have knowledge and understanding of these upcoming trends so that businesses, no matter small or large, can be ready and have access to these business opportunities (Spring News, 2021).

### **The Six Factors**

The six factors which may lead to the success of chat commerce in this study include (1) Perceived Ease of Use, (2) Perceived Usefulness, (3) Compatibility, (4) Subjective Norms, (5) Trust, and (6) Attitude towards chat commerce. These factors are selected from previous research and models. Perceived Ease of Use and Perceived Usefulness is from Davis's Technology Acceptance Model (TAM) (Davis, 1989). Trust is also integrated into TAM in many types of research, such as the one by Gefen, Karahanna, and Straub (2003). Attitude and Subjective Norms are from Fishbein and Ajzen's Theory of Reasoned Action (TRA) (Lyong Ha, 1998). Also, Compatibility has been recognized as an important factor in the adoption of IT innovations (Bunker et al., 2006)

#### ***Perceived ease of use***

Perceived ease of use refers to the degree to which a prospective user expects the target system to be free of effort (Elmorshidy et al., 2015). Most studies on TAM (Technology Acceptance Model) indicated that perceived ease of use directly influenced the use and intention to use. For Thai people who already know how to use chat applications such as LINE or Facebook Messenger as a part of their daily lives, they would find chat commerce an easy way to do online shopping.

#### ***Perceived usefulness***

As another component of TAM, perceived usefulness refers to the perceived benefits of using a specific application system. Perceived usefulness has consistently been a strong determination of the intention to use technology. (Elmorshidy et al., 2015). It is obvious that Thai people would find chat commerce very useful, especially in the post COVID era, because chat commerce can save their time and money, as well as keep them safe at home.

#### ***Compatibility***

Compatibility refers to the degree to which the use of the new technology is perceived to be consistent with the potential users' existing values, previous experience, and needs (Elmorshidy et al., 2015). Thai Internet users prefer using text chat to communicate live with online sales representatives because text chat can give users some privacy, and users do not have to be so innovative to use text chat (Rattanawicha, 2013). In other words, text chat is compatible with Thai users' lifestyles.

#### ***Subjective norms***

Subjective norm or social norm refers to users' perception of whether other important people feel they should engage in the behavior. Several researchers found positive relationships between subjective norms and behavioral intention (Elmorshidy et al., 2015). In Thai culture, youngers always want to listen to and follow what elderlies suggest. As a result, Thai people are mostly obedient and would do what is consistent with the subjective norms.

#### ***Trust***

According to Webster's Dictionary, trust can be defined as an assumed reliance on some person or thing. A confident dependence on the character, ability, strength, or truth of someone or something. Trust can be viewed from several dimensions such as transaction, presentation, product, service, and technology. Trust can be developed and maintained. (Elmorshidy et al., 2015). Many studies indicate that trust is one of the most important factors for customers to do online shopping (Gefen et al., 2003). So, trust can be one important factor to influence Thai people to use chat commerce.

#### ***Attitude***

Attitudes are important predictors of behavior and behavioral intention. (Elmorshidy et al., 2015). It is believed that the attitudes of the target users of information technologies play an important role in the acceptance and use of the technologies. Hence, if Thai people have positive attitudes toward chat commerce, it would be easy for chat commerce to be successful in Thailand.

### **Generation Differences**

According to the Book "Marketing 5.0: Technology for Humanity" (Kotler et al., 2021), Baby Boomer was born between 1946 and 1964. Generation X or Gen X was born between 1965 and 1980. Generation Y or Gen Y was born between 1981 and 1996. And Generation Z or Gen Z was born between 1997 and 2009. It has been widely accepted that there are differences between these four generations in many perspectives. For example, Gen X relates well with the concept of "friends and family," while Gen Z, children of Gen X, is considered the first digital native. Gen Y, the offspring of Baby Boomer, is well educated and strongly associated with social media. All four generations have their own characteristics. Gen Y and Gen Z use digital and social media as a part of their lives, while Gen X uses them more for professional purposes. As a result, Gen Y and Gen Z have gotten more attention from marketers these days.

## **RESEARCH QUESTION AND HYPOTHESES**

The objective of this research is to study six factors that may lead to the success of chat commerce in Thailand by focusing on the differences of these factors between generations. The four generations in this study are (1) Baby Boomer, (2) Gen X, (3) Gen

Y, and (4) Gen Z. The six factors include (1) Perceived Ease of Use, (2) Perceived Usefulness, (3) Compatibility, (4) Subjective Norms, (5) Trust, and (6) Attitude towards chat commerce. The following hypotheses are tested.

H1: Perceived ease of use of chat commerce varies across four generations.

H2: Perceived usefulness of chat commerce varies across four generations.

H3: The compatibility of chat commerce varies across four generations.

H4: Subjective norms towards chat commerce vary across four generations.

H5: Trust in chat commerce varies across four generations.

H6: Attitude towards chat commerce varies across four generations.

## RESEARCH METHODOLOGY

### Research Tools

The main research tool in this study is an online questionnaire, as shown in Figure 1. The questionnaire has three parts. The first part gives definitions and examples of chat commerce. The second part collects demographic data, including respondent's gender, year of birth, experiences with online shopping, and experience with chat commerce. In the third part, respondents are asked to rate their opinions on six factors which are Perceived Ease of Use, Perceived Usefulness, Compatibility, Subjective Norms, Trust, and Attitude towards chat commerce. Each factor has its own attributes, which range from three to six questions. These six factors and questions of each factor are adapted from previous relevant research (Elmorshidy *et al.*, 2015). Ratings for each question are from 5 to 1, which represents strongly agree, agree, neutral, disagree, and strongly disagree, respectively. The questionnaire was tested in a pilot study and improved for the actual data collection. Details of questionnaire development are explained in the next section.

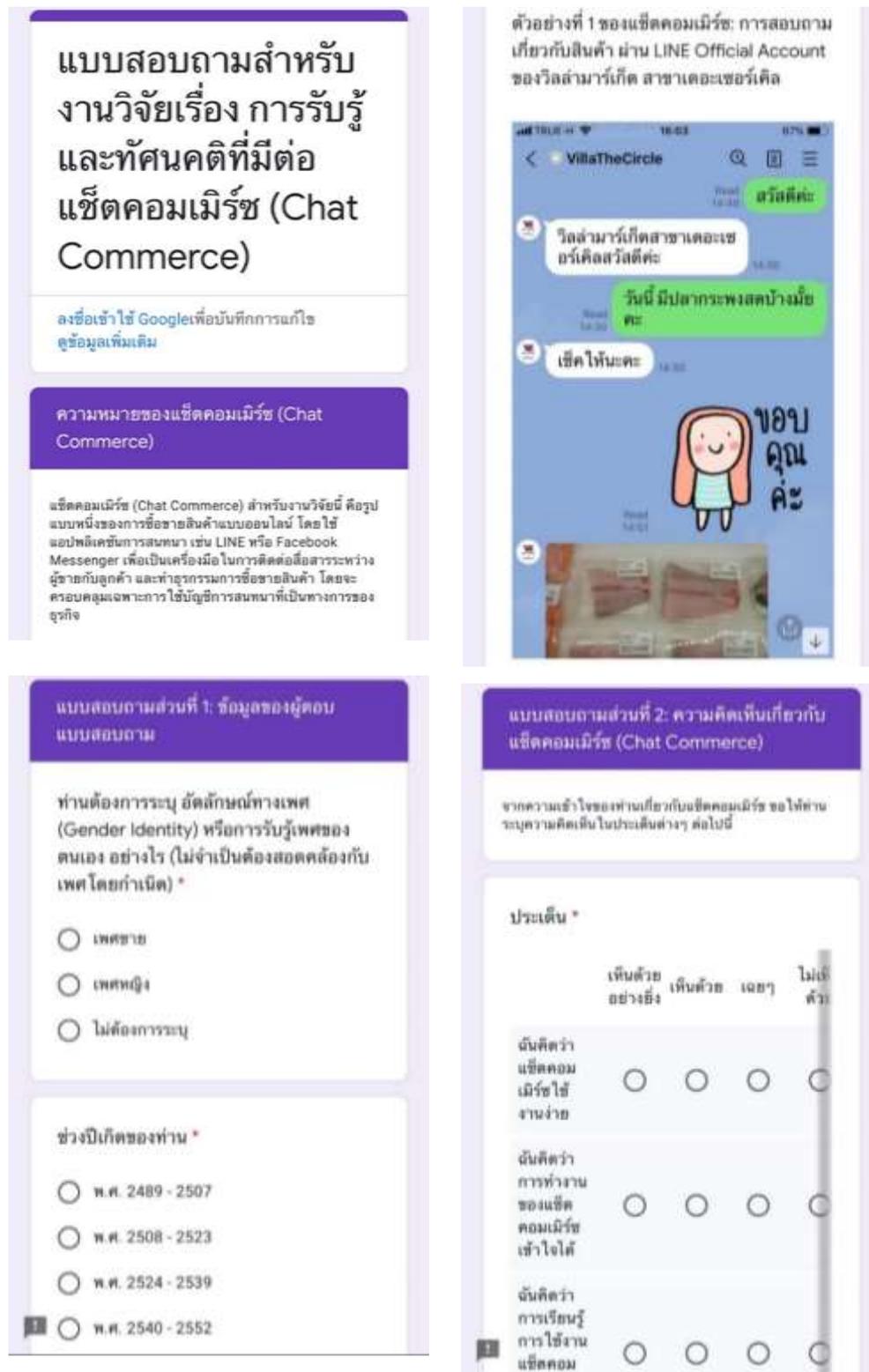
### Questionnaire development

Twenty-five question items to measure six factors (3 items for perceived ease of use, six items for perceived usefulness, three items for compatibility, three items for subjective norms, five items for trust, and five items for attitude, adapted from previous research) were translated to Thai and arranged in a questionnaire format in Google Forms. The questionnaire then was tested for its validity and reliability in a pilot survey with 30 respondents (7 Baby Boomer respondents, 8 Gen X respondents, 7 Gen Y respondents, and 8 Gen Z respondents). After adjusting some of the questions from the pilot study results, the final Thai version of the questionnaire was ready for the actual data collection. Table 1 presents the English version of the final questionnaire.

### Population and Data Collection

According to data in 2020 from the National Statistical Office of Thailand ([http://ittdashboard.nso.go.th/index\\_en.php](http://ittdashboard.nso.go.th/index_en.php)), the proportion of Thai population for these four generations is about 14% for Baby Boomer, 36% for Gen X, 26% for Gen Y, and 24% for Gen Z. Hence, data for this study is collected from Thai participants for each of the four generations using these proportions. Also, we try to maintain the ratio of 60% female and 40% male shoppers in Thailand (itoplus.com, 2020).

A total of 253 respondents participated in the data collection via Google Forms in July 2021. The demographics of these 253 respondents are presented in Table 2. The participants are 13.8% Baby Boomer, 36.4% Gen X, 26.1% Gen Y, and 23.7% Gen Z. 38% of them are males, and 58.1% are female. 182 (71.9%) of them have chat commerce experiences. And these participants with chat commerce experiences are 12.1% Baby Boomer, 38.5% Gen X, 25.3% for Gen Y, and 24.1% Gen Z.



Source: This study.

Figure 1: Questionnaire in google forms.

Table 1: English version of the final questionnaire.

Construct	Questionnaire Items
Perceived Ease of Use	E1 - I think chat commerce is easy to use. E2 - I think the way chat commerce works is understandable. E3 - I think it is easy to learn to use chat commerce.

Construct	Questionnaire Items
Perceived Usefulness	U1 - Chat commerce helps people to get the information needed about the product and purchase process. U2 - Chat commerce can be used to inquire about discounts or promotions. U3 - Chat commerce can be used for agreeing on payment and delivery of goods. U4 - Chat commerce makes online shopping convenient and fast. U5 - Chat commerce can be used for asking for help if there is a problem with online shopping. U6 - Chat commerce is useful for those who want to shop online.
Compatibility	C1 - Shopping via chat commerce fits my lifestyle. C2 - Shopping via chat commerce is suitable for my current situation. C3 - Shopping via chat commerce is my preferred method of online shopping.
Subjective Norms	N1 - I think my friends will encourage me to use chat commerce. N2 - I think the person I trust will recommend me to use chat commerce. N3 - I think people who shop online will use chat commerce when given the opportunity.
Trust	T1 - Technology that supports chat commerce is reliable. T2 - I think staffs who talk to customers in chat commerce are knowledgeable and able to serve customers. T3 - I think staffs who talk to customers in chat commerce have the intention to help customers solve their problems. T4 - I think staffs who talk to customers in chat commerce have integrity in their services. T5 - I think the staff who talk to customers in chat commerce will not disclose personal information of customers.
Attitude	A1 - I feel good to use chat commerce to shop online. A2 - I feel good talking to staff in chat commerce. A3 - I feel good when I receive an offer in chat commerce that meets my needs. A4 - I have a positive attitude towards commerce. A5 - I will recommend people I know to use chat commerce.

Source: Adapted from previous studies.

Table 2: Respondents' demographic information.

Demographics	Distribution
<b>Generation</b>	35 (13.8%) Baby Boomer 92 (36.4%) Gen X 66 (26.1%) Gen Y 60 (23.7%) Gen Z
<b>Gender</b>	96 (38.0%) Male 147 (58.1%) Female 10 (3.9%) Unidentified
<b>Chat commerce experience</b>	13 (5.2%) No online shopping Experience 58 (22.9%) With online experience, no chat commerce experience 182 (71.9%) With chat commerce experience
<b>Generation of respondents with chat commerce experience</b>	22 (12.1%) Baby Boomer 70 (38.5%) Gen X 46 (25.3%) Gen Y 44 (24.1%) Gen Z
<b>Gender of respondents with chat commerce experience</b>	60 (33.0%) Male 114 (62.6%) Female 8 (4.4%) Unidentified

Source: This study.

## RESEARCH RESULTS

### Descriptive Statistics

#### *Factors and attributes*

Table 3 presents descriptive statistics of each factor. The second column represents the number of attributes under the factors. Cronbach's Alphas displayed in the third column are all higher than 0.80, indicating the high quality of the questionnaire. Mean values and standard deviation of each factor are also calculated for each generation. Table 3 indicates that Gen Z has the highest opinion mean scores in perceived ease of use, perceived usefulness, and trust. On the other hand, Baby Boomer, Gen X, and Gen Y do not have many differences in opinion mean scores. We also find from Table 3 that all four generations give the top two highest opinion scores to Perceived Ease of Use and Perceived Usefulness of chat commerce. Moreover, Trust in chat commerce receives the lowest average scores from all four generations.

Table 3: Descriptive statistics of each factor.

Factors	Attributes	Cronbach's Alpha	Mean (Standard Deviation)			
			Baby Boomer	Gen X	Gen Y	Gen Z
Perceived Ease of Use	E1 – E3	0.889	4.32 (0.47)	4.20 (0.51)	4.20 (0.69)	4.46 (0.53)
Perceived Usefulness	U1 – U6	0.813	4.26 (0.39)	4.27 (0.52)	4.24 (0.58)	4.44 (0.53)
Compatibility	C1 – C3	0.814	4.09 (0.54)	4.01 (0.71)	4.11 (0.76)	4.08 (0.79)
Subjective Norms	N1 – N3	0.852	3.95 (0.68)	3.79 (0.72)	3.99 (0.70)	3.98 (0.69)
Trust	T1 – T5	0.840	3.54 (0.53)	3.57 (0.49)	3.88 (0.58)	3.90 (0.75)
Attitude	A1 – A5	0.897	3.96 (0.57)	3.81 (0.66)	3.99 (0.67)	3.95 (0.73)

Source: This study.

### Hypothesis Testing

#### Factors comparison for all four generations

First, we test each factor to see whether there are differences across four generations by using Dunn's test under the alternative hypothesis  $H_a$ : The factors' average scores vary across four generations. Dunn's test is Kruskal-Wallis multiple comparisons which p-values adjusted with the Bonferroni method (Dunn, 1964). Dunn's test is being considered because the collected data of each factor do not have a normal distribution. Along with the analysis, hypothesis testing uses a 5% significance level.

Table 4 indicates that there are only two factors with significant differences in average scores across generations, Perceived Ease of Use and Trust. For Perceived Ease of Use, Gen Z has significantly higher average scores than those of Gen X. For Trust, Gen Z has significantly higher average scores than those of Baby Boomer and Gen X. Also, Gen Y has significantly higher Trust in chat commerce than Gen X.

Table 4: P-value from Dunn's test when factors are different between generations.

Factors	Baby Boomer vs.			Gen X vs.		Gen Y vs.
	Gen X	Gen Y	Gen Z	Gen Y	Gen Z	Gen Z
Perceived Ease of Use	1.000	1.000	1.000	1.000	0.035**	0.494
Perceived Usefulness	1.000	1.000	0.884	1.000	0.332	0.545
Compatibility	1.000	1.000	1.000	1.000	1.000	1.000
Subjective Norms	1.000	1.000	1.000	0.464	0.774	1.000
Trust	1.000	0.087	0.047**	0.026**	0.011**	1.000
Attitude	1.000	1.000	1.000	0.478	1.000	1.000

Source: This study.

\*\* significant at 95% confidence level

#### Attributes comparison for all four generations

Since there are not many differences for the "Factor" level as indicated in Table 4, we test each attribute individually to see whether there are differences between generations for the "Attribute" level using Dunn's test under the alternative hypothesis  $H_a$ : The attributes' average scores vary across four generations. Table 5 indicates only the attributes that have significant differences between generations with the p-value inside the table. The hypothesis testing uses a 5% significance level. It is clearly shown that Baby Boomer and Gen X have no significant average differences for all attributes. Moreover, when comparing Gen Y with Baby Boomer and Gen X, the difference appears only in attribute T4. In contrast with Gen Z, the differences occur in several attributes, and especially when compared with Gen X. Therefore, in the next section, the analysis will be considered grouping Baby Boomers, Gen X and Gen Y together, then comparing with Gen Z. Table 6 presents descriptive statistics of the

attributes that have the differences between generations from Table 5.

Table 5: P-value from Dunn's test when attributes are different between generations.

Attributes	Baby Boomer vs			Gen X vs		Gen Y vs
	Gen X	Gen Y	Gen Z	Gen Y	Gen Z	Gen Z
E3	0.685	1.000	0.394	1.000	0.001**	0.029**
U1	1.000	1.000	0.063	1.000	0.003**	0.003**
U5	0.350	0.378	0.012**	1.000	0.172	0.283
T2	1.000	0.099	0.039**	0.093	0.025**	1.000
T3	1.000	0.176	0.092	0.078	0.029**	1.000
T4	0.957	0.008**	0.002**	0.015**	0.002**	1.000
T5	1.000	0.076	0.035	0.089	0.032**	1.000

Source: This study.

\*\* significant at 95% confidence level

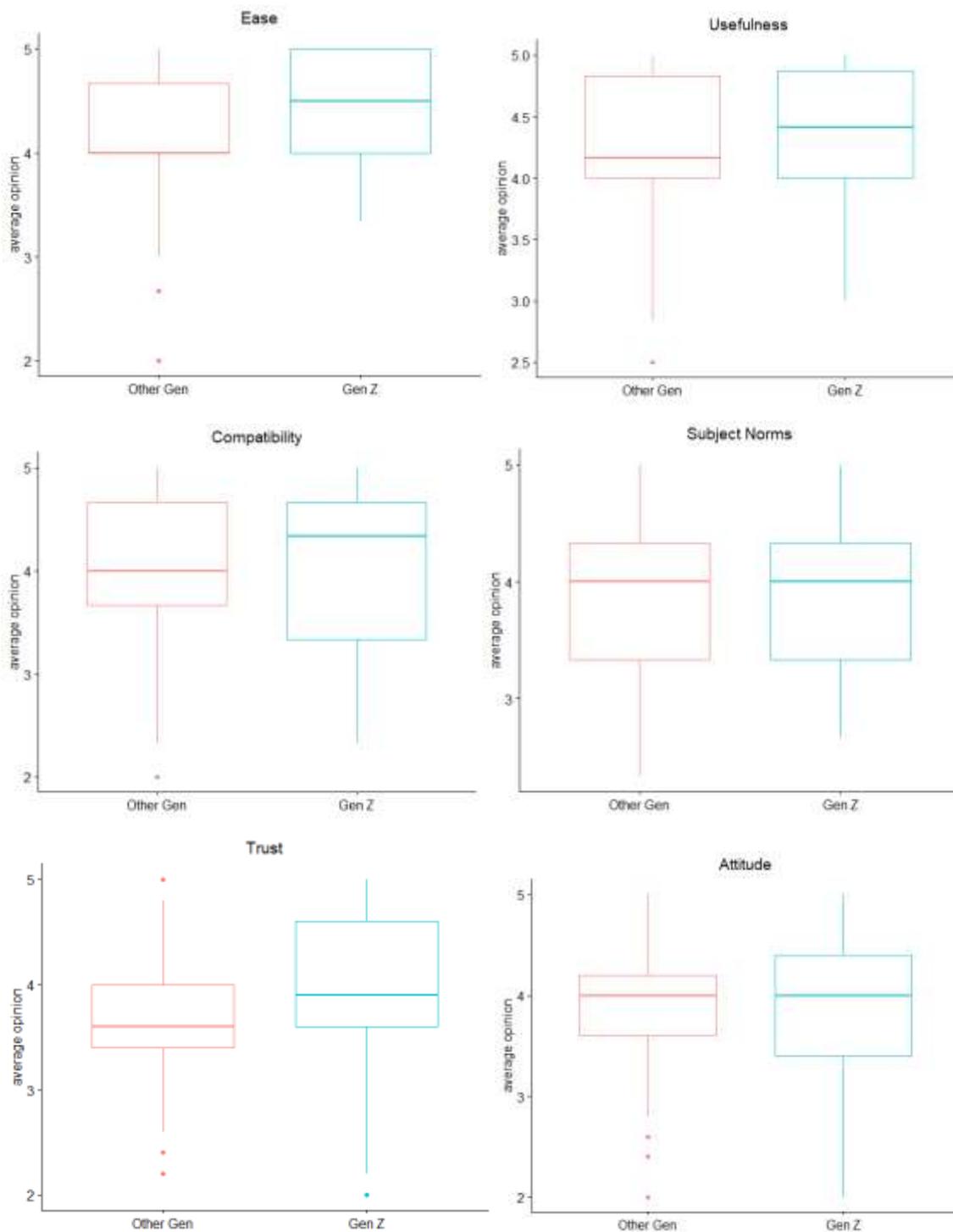
Table 6: Descriptive statistics of each attribute with significant differences between generations.

	Attributes	Mean (Standard Deviation)			
		Baby Boomer	Gen X	Gen Y	Gen Z
E3	I think it is easy to learn to use chat commerce.	4.36 (0.49)	4.17 (0.56)	4.20 (0.78)	4.57 (0.55)
U1	Chat commerce helps people to get the information needed about the product and purchase process.	4.27 (0.55)	4.24 (0.58)	4.13 (0.83)	4.61 (0.62)
U5	Chat commerce can be used for asking for help if there is a problem with online shopping.	3.91 (0.68)	4.14 (0.84)	4.17 (0.80)	4.43 (0.76)
T2	I think staffs who talk to customers in chat commerce are knowledgeable and able to serve customers.	3.59 (0.73)	3.74 (0.56)	4.00 (0.70)	4.07 (0.76)
T3	I think staffs who talk to customers in chat commerce have the intention to help customers solve their problems.	3.68 (0.78)	3.73 (0.68)	4.04 (0.76)	4.02 (0.98)
T4	I think staffs who talk to customers in chat commerce have integrity in their services.	3.41(0.67)	3.59 (0.63)	4.00 (0.79)	4.07 (0.90)
T5	I think the staff who talk to customers in chat commerce will not disclose the personal information of customers.	3.05 (0.72)	3.14 (0.79)	3.52 (0.81)	3.57 (0.99)

Source: This study.

**Factors comparison for gen Z and other generations**

From Table 7, Perceived Ease of Use, Perceived Usefulness, and Trust are factors that present the significant differences between Gen Z and other generations. Moreover, Figure 2 shows boxplots of all six factors. When compare between Gen Z and other generations, it is clearly shown that Gen Z gives the highest average opinion scores, which apply to all significant factors. Consequently, the analysis in Table 7 builds from the one-sided alternative hypothesis  $H_a$ : Gen Z has higher average scores.



Source: This study.

Figure 2: Boxplots comparison between gen Z and other generations.

Table 7: Mean score, standard deviation, and p-value of factors comparison between gen Z and other generations.

Factors	Gen Z	Other Generations	P-value
Perceived Ease of Use	4.46 (0.53)	4.22 (0.57)	0.012**

Perceived Usefulness	4.44 (0.53)	4.26 (0.52)	0.035**
Compatibility	4.08 (0.79)	4.06 (0.70)	0.647
Subjective Norms	3.98 (0.69)	3.88 (0.71)	0.418
Trust	3.90 (0.75)	3.67 (0.55)	0.012**
Attitude	3.95 (0.73)	3.90 (0.65)	0.681

Source: This study.

\*\* significant at 95% confidence level

#### Attributes comparison for gen Z and other generations

Table 8 focuses on attributes inside the three factors which respondents give significantly different average opinion scores (Perceived Ease of Use, Perceived Usefulness, and Trust from Table 7). The results in Table 8 are from the alternative hypothesis  $H_a$ : Attribute of generation Z is different from other generations. The Dunn's test will again be used, and all attributes which have differences between two groups of generations, generation Z and other generations, are shown in Table 8.

Table 8: Mean score, standard deviation, and p-value of attributes that are different between gen Z and other generations.

	Factors	Gen Z	Other Generations	P-value
E1	I think chat commerce is easy to use.	4.39 (0.69)	4.19 (0.63)	0.043**
E2	I think the way chat commerce works is understandable.	4.43 (0.66)	4.25 (0.58)	0.044**
E3	I think it is easy to learn to use chat commerce.	4.57 (0.55)	4.21 (0.63)	0.001**
U1	Chat commerce helps people to get the information needed about the product and purchase process.	4.61 (0.62)	4.21 (0.67)	0.000**
U5	Chat commerce can be used for asking for help if there is a problem with online shopping.	4.43 (0.76)	4.12 (0.80)	0.015**
U6	Chat commerce is useful for those who want to shop online.	4.50 (0.79)	4.35 (0.64)	0.045**
T2	I think staffs who talk to customers in chat commerce are knowledgeable and able to serve customers.	4.07 (0.76)	3.80 (0.65)	0.023**
T3	I think staffs who talk to customers in chat commerce have the intention to help customers solve their problems.	4.02 (0.98)	3.83 (0.73)	0.034**
T4	I think staffs who talk to customers in chat commerce have integrity in their services.	4.07 (0.90)	3.70 (0.72)	0.003**
T5	I think the staff who talk to customers in chat commerce will not disclose the personal information of customers.	3.57 (0.99)	3.25 (0.80)	0.028**

Source: This study.

\*\* significant at 95% confidence level

## DISCUSSION AND CONCLUSION

From this study, it can be concluded that for the six factors which may lead to the success of chat commerce in Thailand, the two most important factors are Perceived Ease of Use and Perceived Usefulness. This is true for all four generations in the study. Perceived Ease of Use and Perceived Usefulness are the two main factors of the Technology Acceptance Model (TAM). So, this study adds to the solid explanation of TAM as a basic and classic model for users to accept and use technology, including chat commerce. It is also found from the study that Gen Z gives the highest scores to all six factors. This is consistent with the characteristics of Gen Z, the first digital native, because digital and social media are parts of their lives. To promote chat commerce in Thailand even further, businesses can look into attributes of each factor to gain a better understanding of how users from each generation perceive or give their opinions towards those attributes of factors. This can lead to better services and more uses of chat commerce in Thailand.

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## Supporting Learning and Working in Disastrous Pandemics by Smart Technologies: A Qualitative Analysis

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### ABSTRACT

During the breakout of coronavirus disease (COVID-19), smart technologies were perceived to provide convenience and assistance for people, enterprises, and government units. Although there is literature maintaining that smart technology can facilitate pandemic strategy and response in ways that are difficult to achieve manually, some other literature indicated that smart technologies were not desirable alternatives to people during this pandemic. MIS education is a career preparation for IT professionals who use smart technology in organizations. IT professionals with MIS education backgrounds may have important roles when facing COVID-19. Moreover, many MIS students will become IT professionals and join the workforce for combatting the pandemic using smart technologies with their background of MIS education. This study intends to analyze smart technology utilization in the confrontation of the COVID-19 pandemic with a qualitative approach. The results could provide reflective insights for MIS education providers, human resource units, IT firms, and organizations confronting COVID-19 outbreaks.

*Keywords:* Management information system, education, IT professional, smart technology, COVID-19.

### INTRODUCTION

Since the beginning of 2020, the world has been confronting the epidemic of coronavirus disease (COVID-19). To prevent the contagion, many countries have restricted transportation, grounded airlines, closed public facilities, blocked traffics, sealed cities, and quarantined residents, making the provision of goods and services extremely difficult (Whitelaw *et al.*, 2020). During this abnormal period, electronic governments and businesses taking advantage of digital technologies (DT) provide emergency reliefs to the people and organizations in need at home or worldwide under this disastrous situation (Tuli *et al.*, 2020).

However, the perceptions of using smart technologies to assist the countering of the pandemic are divided. There is literature that maintains that digital technology can facilitate pandemic strategy and response in ways that are difficult to achieve manually (Whitelaw *et al.*, 2020). Some other literature indicated that technologies such as smartphones, tablets, and PC were not desirable alternatives to regular voice-based phones during this pandemic (Kjerkol *et al.*, 2021). These opposite views on the effectiveness of using smart technologies for coping with the COVID-19 pandemic require further study for deeper insight into pandemic confrontation.

Moreover, IT professionals are key actors in the utilization of smart technologies. They are people with IT skills to help the confrontation of contingencies for governments, enterprises, and other organizations. Therefore, IT professionals could be an important linkage resource between digital technologies and the COVID-19 confrontation. Furthermore, many IT professionals have an educational background in management information systems (MIS). Their professional careers start with the knowledge obtained from MIS education. Thus, the role of MIS education may also be relevant in the connection between digital technologies and the confrontation with COVID-19. However, despite these possible connections, so far, the research on the relations of COVID-19 confrontation, smart technology utilization, IT professionals, and MIS education are very scant. Therefore, the objective of this research is to investigate and clarify the possible linkages.

The paper begins with a review of the relevant literature about the relationships among the COVID-19 pandemic, smart technologies, IT professionals, and MIS education. Then it explains the research setting for this study. Following that, the process of data collection and the results of data analysis are elaborated. Finally, a discussion with implications and conclusions with suggestions are provided.

### RESEARCH BACKGROUND

#### Smart Technology and COVID-19 Outbreaks

The year 2020 was a difficult time for the whole world. The outbreak and widespread of the COVID-19 pandemic changed the lives of many people. During this hard time, governments and enterprises worldwide have utilized various smart technologies to avert further deterioration of the situation (Gong *et al.*, 2020; Whitelaw *et al.*, 2020).

Contemporary smart technology is considered as “the next big thing” (Borgia, 2014; Marinova *et al.*, 2017; Porter & Heppelmann, 2015) by many countries and organizations. Several researchers have elaborated the technological features of the smart

technologies (Agarwal & Brem, 2015; Atzori *et al.*, 2010; Borgia, 2014; Bradley *et al.*, 2015; Gubbi *et al.*, 2013; Krotov, 2017; Miorandi *et al.*, 2012; Porter & Heppelmann, 2015; Yoo *et al.*, 2010). In Table 1, these features are classified and summarized using the layered modular architecture (Yoo *et al.*, 2010).

Table 1: Layered modular architecture of smart technologies.

Layer	Module	Feature	Reference
Content	Real-time analytics	Sensor monitored and detected information is invisibly embedded in the environment around users, resulting in the generation of big data in real-time, which are distributed, stored, processed, presented, and interpreted in a seamless, efficient, and easily understandable form.	(Gubbi <i>et al.</i> , 2013; Krotov, 2017; Weng & Lin, 2013)
	Cyber-physical convergence	The convergence of computer networks, telecom networks, and the IoT triggers further convergence of cyberspace and physical space and results in various smart spaces, such as smart home, smart office, smart factory, smart laboratory, smart store, smart marketplace, smart hospital, smart museum, and smart city.	(Agarwal & Brem, 2015; Bradley <i>et al.</i> , 2015; Gubbi <i>et al.</i> , 2013; Miorandi <i>et al.</i> , 2012)
Service	Cloud support	Cloud services are deployed to assist the processing and storage of big data analytics and provide users ubiquitous access to supporting services initiated by devices around the smart environment.	(Atzori <i>et al.</i> , 2010; Bradley <i>et al.</i> , 2015; Gubbi <i>et al.</i> , 2013; Weng & Lin, 2014)
	Intelligent interface	Visualization, touching, and voice are critical for smart applications as they allow the awareness and interaction of users with the environment. 3D viewing and printing technologies, personal mobile assistants, wearable devices, and augmented-reality devices provide a novel interface for users to interact with the smart environment.	(Bradley <i>et al.</i> , 2015; Gubbi <i>et al.</i> , 2013)
Network	Pervasive connectivity	Smart mobile devices and the IoT contains multiple layers of communication networking infrastructure to provide pervasive communications between people and people, people and things, and things and things, to form a smart environment.	(Atzori <i>et al.</i> , 2010; Gubbi <i>et al.</i> , 2013; Yoo <i>et al.</i> , 2010)
	Seamless streaming	Wireless broadband technologies enable robust streaming of digital content data through broadband wireless networks for multimedia applications and services on demand.	(Borgia, 2014; Gubbi <i>et al.</i> , 2013; Krotov, 2017)
Device	Ubiquitous sensing	This is the mechanism that the “things” or devices in the IoT perceive the surrounding physical environment, detect and record the changes in the environment, and respond to the changes. Ubiquitous sensing is enabled by wireless sensor network (WSN) technologies.	(Borgia, 2014; Bradley <i>et al.</i> , 2015; Gubbi <i>et al.</i> , 2013)
	Embedded computing	Smart mobile devices contain embedded hardware and software to work intelligently within the environment. The embedded hardware includes processor chips, data storage units, and power units. The embedded software includes embedded operating systems, mobile apps, and middleware. In particular, the devices can be modularly embedded further in other devices.	(Gubbi <i>et al.</i> , 2013; Krotov, 2017; Weng & Lin, 2015)
	Interconnected smart products	Smart technologies enable the evolution of various products such as smart home appliances, robots, drones, unmanned cars, automated factory machines and business equipment, and many other innovative devices.	(Krotov, 2017; Miorandi <i>et al.</i> , 2012; Porter & Heppelmann, 2015; Weng, 2021)

Source: This study.

The critical capabilities of smart technologies include the empowerment of highly personalized, customized, and adaptable products and services (Porter & Heppelmann, 2015) and the dynamic decision support through situational sensing, monitoring, and learning (Marinova *et al.*, 2017).

With these technological features, smart technologies have been applied in various confrontation scenarios of COVID-19. Table 2 provides examples of applications using smart technologies for confronting the COVID-19 epidemic. The industry experts and literature suggest that critical functionalities coping with pandemic situations include management of surveillance (Ibrahim, 2020), collaboration (Zhao & Wu, 2020), and mobility (Moslem *et al.*, 2020).

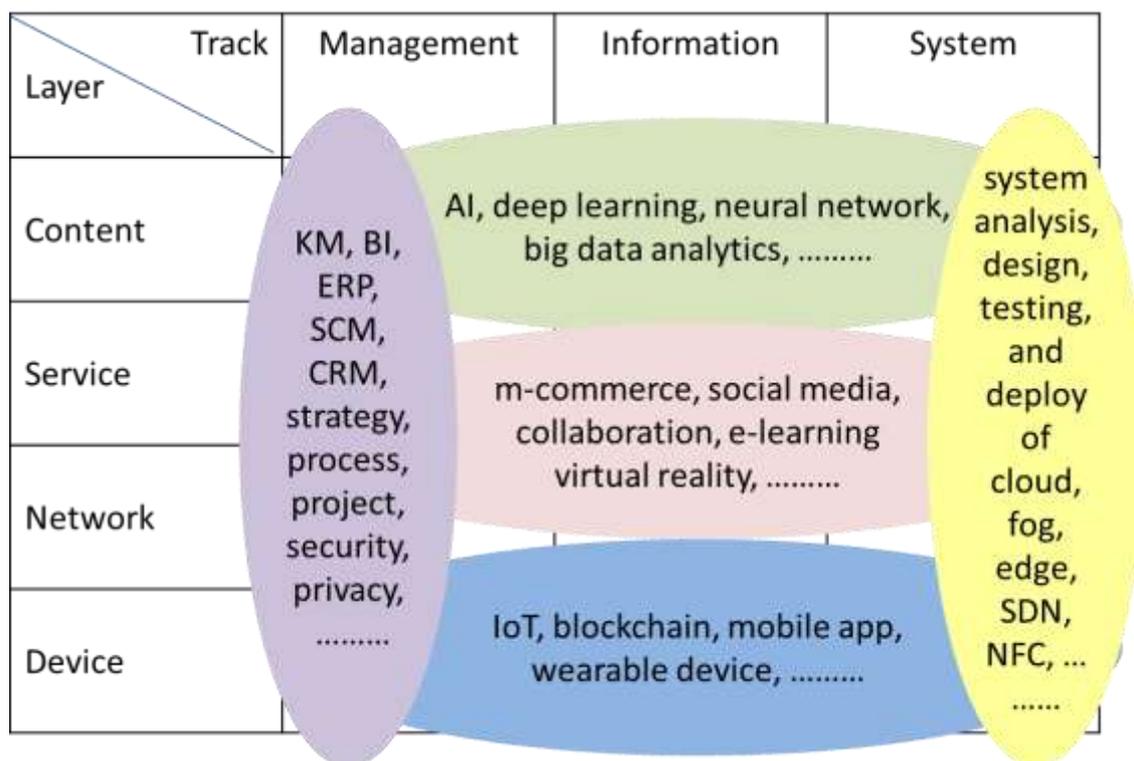
Table 2: Examples of IT applications for COVID-19 confrontation.

Sector \ Functionality	Government	Business	Individual
Surveillance	Public health status and medical data detection	Employee locations and health status tracing	Personal health information; Footprint timeline tracing
Collaboration	Logistics and distribution of healthcare materials	Remote co-working and employee collaboration; Supply chain flexibility	Social media and instant messaging
Mobility	Remote public services and distance education	Online marketing and selling; Mobile commerce	Mobile shopping and entertainment on demand

Source: This study.

### MIS Education and IT Professionals

Each year, many students who graduated from university MIS (or similar) education programs join the workforce of IT professionals and play a pivotal role in the utilization of digital technologies to serve in various sectors of organizations. Figure 1 exhibits an example of a smart technology curriculum in the MIS education program.



Source: This study.

Figure 1: A smart technology curriculum in MIS education program.

Figure 1 shows that a core MIS curriculum is designed to invoke the attention and relevance of MIS students to the development and application of smart technologies. With this educational background in the MIS discipline, they are expected to be confident and perform their duties with satisfying results.

However, the real world is always full of various challenges. Starting from the year 2020, MIS graduates are facing one more challenge that is not seen in human history: the outbreak of COVID-19.

### MIS Students and COVID-19 Outbreaks

There is literature that maintains that digital technology can facilitate pandemic strategy and response in ways that are difficult to achieve manually (Whitelaw *et al.*, 2020). Since MIS education is a career preparation for IT professionals who use digital technology in organizations, MIS education and IT professionals should become critical when facing COVID-19 (Dwivedi *et al.*, 2020).

However, some other literature argued that technologies such as smartphones, tablets, and PC were not desirable alternatives to regular voice-based phones during this pandemic situation (Kjerkol *et al.*, 2021). This counter proposition weakened the role of digital technologies facing COVID-19; thus, it may also depreciate the impacts of MIS education and IT professionals on coping with the pandemic (Pflügler *et al.*, 2018).

Therefore, opposite views exist on the connections between smart technologies and COVID-19 confrontation. This contradiction triggers the question that many MIS students will become IT professionals and join the workforce for combatting the pandemic using digital technologies with their background of MIS education. How do they use smart technologies to face the pandemic?

Therefore, this study aims to answer the following research question: How useful are smart technologies to MIS students (i.e., the future IT professionals) for COVID-19 confrontation and life transition?

## RESEARCH METHOD

### Research Setting and Data Collection

This study intends to depict the relevance of smart technologies in the confrontation of the COVID-19 pandemic. A qualitative approach with participatory observation is adopted (Clark *et al.*, 2009).

Data for this study were collected through participatory observation, archived data, and informal conversation. Data collection activities were started in the middle of April 2021 and took about thirty days to complete. Table 3 exhibits data collection methods.

Table 3: Data Collection.

Data source	Data collection process
Participatory observation	<ul style="list-style-type: none"> <li>● Totally seven occasions with an average time length of ninety minutes. Include:</li> <li>● two online course meetings</li> <li>● one online homework discussion with classmates</li> <li>● two distance conferences with work colleagues</li> <li>● two occasions of working from home</li> </ul>
Informal dialog	<ul style="list-style-type: none"> <li>● Five conversations with two MIS professors, one of which has been a department chair</li> <li>● Three conversations with a corporate CIO and an MIS team</li> <li>● Four conversations with a senior VP of a recruitment website</li> </ul>
Archived data	<ul style="list-style-type: none"> <li>● MIS education program descriptions on the university websites</li> <li>● Recruiting advertisements for IT professionals</li> <li>● Attending two public, corporate conferences held by IT companies</li> <li>● Discussion of life and social experience on social media</li> <li>● News and commentaries about COVID-19 outbreaks and social phenomena</li> </ul>

Source: This study.

### Recruiting Procedure

This study used purposive sampling with a snowballing method to recruit participants. In the sampling, we have ruled out students of our affiliated school. Data collection by interviews was conducted in April of 2021. Totally six interviewees with diverse backgrounds from different universities in Taiwan and USA participated in this study. At the time of the study, some of them were senior MIS students, some of them were master-level MIS students, and the others were recent graduates from MIS programs and worked for less than two years. These participants are as shown in Table 4.

Table 4: Participant description.

Case name	Status at the time of this study	Affiliated school location
Student Chen	<ul style="list-style-type: none"> <li>● Senior undergraduate MIS student</li> <li>● Studied accounting before transferring to MIS</li> <li>● Part-time work in pharmacy sector for one year</li> </ul>	Northern Taiwan
Student Fang	<ul style="list-style-type: none"> <li>● Senior undergraduate MIS student</li> <li>● Assisting a project about cloud security and social media privacy</li> <li>● Summer practicum at a medical equipment manufacturer</li> <li>● Summer practicum at an online retailer</li> </ul>	California, USA
Student Guo	<ul style="list-style-type: none"> <li>● First-year master level MIS graduate student</li> <li>● Two years of working experience in the finance sector</li> <li>● Part-time working experience at a gym</li> </ul>	Northern Taiwan

	<ul style="list-style-type: none"> <li>● Self-study of herbal medicine</li> </ul>	
Student Lin	<ul style="list-style-type: none"> <li>● Second-year master level MIS graduate student</li> <li>● Working on a thesis about comparing agile development model and waterfall model</li> <li>● One year of working experience in the media sector</li> <li>● Part-time volunteer service in the healthcare sector</li> </ul>	Texas, USA
Student Wu	<ul style="list-style-type: none"> <li>● Graduated from undergraduate MIS program</li> <li>● Working for two years in the MIS unit of the manufacturing sector</li> <li>● Traveled to China and Korea several times for work assignments during the COVID-19 outbreak</li> </ul>	Northern Taiwan
Student Yeh	<ul style="list-style-type: none"> <li>● Graduated from master MIS program</li> <li>● Master project of using neural network and data mining to analyze supply chain data</li> <li>● Working for one year in the MIS unit of the retail sector</li> <li>● Six months of civil service in a hospital on an outer island of Taiwan</li> </ul>	California, USA

Source: This study.

### Data Analysis

The data of this study were analyzed after the data collection stage. The observation logs were transcribed to form the significant data for analysis in this study. Data clarification was made by contacting the participants when there were ambiguous or missing contexts. After the observations, the researcher analyzed the behavior of the participants and extracted the encapsulated meanings.

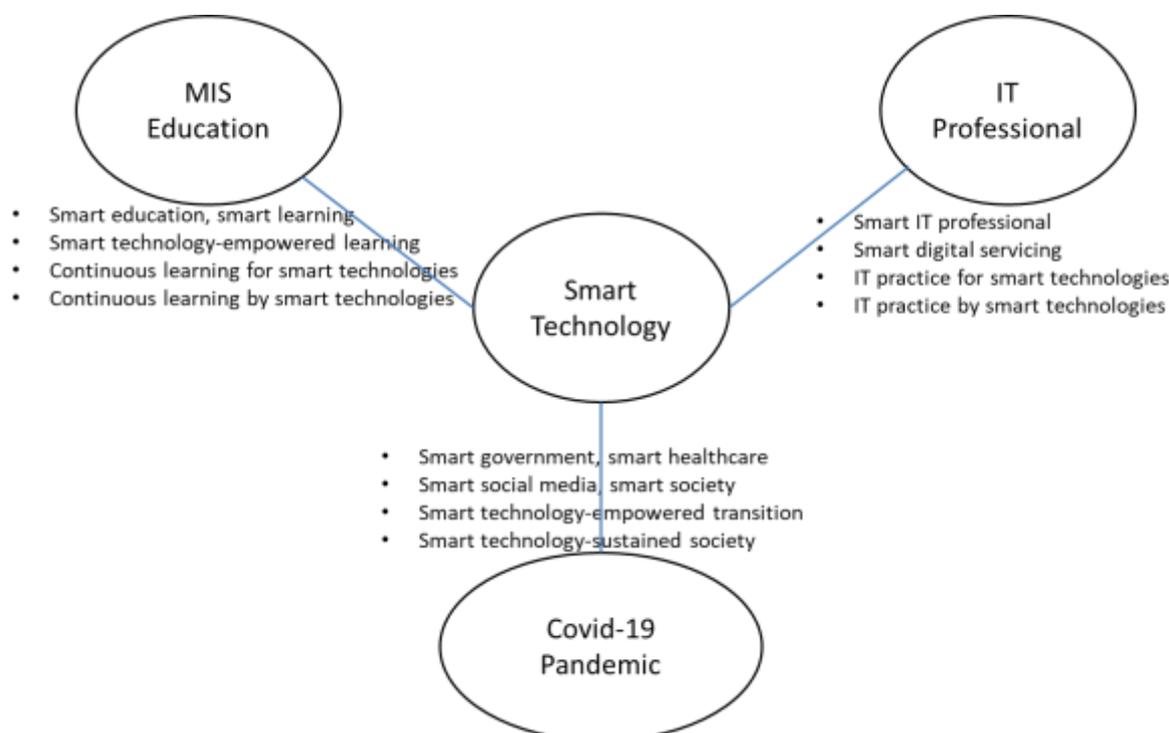
## RESULTS

The results are discussed toward two focal points: the role of smart technologies and the possible transitions by smart technologies. These focal points are illustrated as follows.

### Smart Technologies as a Supportive Platform

In our analysis of the data, we found the role of smart technology quite subtle. It was a hidden role since we did not specifically ask the participants about their perceptions of smart technologies. However, it became clear in the observations that smart technology is actually a leading role. Its role is inevitable and indispensable. This is further evidenced by our participatory observation (see Table 3).

Figure 2 depicts the empowering role of smart technologies from the lens of the participants.



Source: This study.

Figure 2: Exploiting smart technologies.

For example, we observed how the participants achieved their continuous learning and intellectual preparation during the disruptive time of COVID-19 outbreaks. They need to do that using their smart mobile devices through the established digital

infrastructure and technology integration. Their learning and adapting are empowered, for example, by smart mobile devices, cloud-supported learning, streaming of contents, and cyber-physical convergence for virtual classrooms (see Table 1).

Also, we observed how the recent graduates as IT professionals perform their agile servicing and technology integration practices under COVID-19 disasters. They can do that efficiently with the remote and mobile collaboration of work through smart technologies they had learned since their MIS education and continuous learning. Their practice and service are empowered, for example, by real-time big data analytics for requirement changes, pervasive connectivity for work collaboration, intelligent interface for prototype demonstration, and embedded computing for product automation (see Table 1).

Moreover, how could we, as members of our society, sustain lifestyle disruption, pervasive anxiety, and public uncertainty caused by the COVID-19 pandemic? Various archival data (see Table 3) indicated that many people sustained the pandemic with the help of the smart technology-empowered services (see Table 2) from the governments, healthcare providers, social media, online retailers, and numerous volunteer organizations using the digital infrastructure and integrated applications developed by IT professionals.

### **Smart Technology Empowered Transitions**

The examples of the participants demonstrate the mechanism of smart technology-empowered transition facing COVID-19 outbreaks. They utilized smart technologies to facilitate the transition of their lives during the difficult time of the COVID-19 pandemic. Specifically, while the MIS students were learning for smart technologies in their MIS education, they were also using smart technologies to facilitate their learning. Likewise, while the IT professionals were working on the development and integration of smart technologies, they were also using smart technologies to facilitate their work.

In our observations, we found that the participants tend to motivate their transitions in a difficult time with two different paths. Some participants expressed that COVID-19 outbreaks make them think about the transition of role. IT professionals facing COVID-19 outbreaks are similar to the medical doctors and nurses combatting COVID-19, who need not only confidence and satisfaction but also volition and reflection to go on. Smart technologies are utilized to facilitate continuous learning in this regard. The other participants emphasized the transition of practice and experience by exploiting smart technologies in pandemic situations. One needs to exercise system thinking, become a problem solver, and deliver workable solutions in unexpected pandemic scenarios.

After the observed results were obtained, this study presented the preliminary outcome to experts in academics and the IT industry. For further discussion (listed as informal dialog in Table 3). The experts offered their views and confirmed these applicable transition paths for the participants from academic and practitioner perspectives, respectively. The transition can be realized with the motivation model of learning (Keller, 2016). The motivation model of learning contains a synthesis of motivational and volitional concepts and theories that provide a foundation for a motivational design process that has been validated in various contexts (Chang *et al.*, 2020; Keller, 2016). In this study, we broaden the scope of learning in the motivation model from education to include practice and experience. Figure 3 shows the observed road map of motivating transitions linking smart technologies with COVID-19 confrontation.

## **DISCUSSION AND CONCLUSIONS**

### **Implications**

The observations lead us to the reflection about how to learn, work, adapt, and sustain facing COVID-19 outbreaks through the utilization of smart technologies. The above discussion illustrated that the real power of smart technologies lies in their hidden yet profound role in facilitating the transition of lives facing uncertain situations.

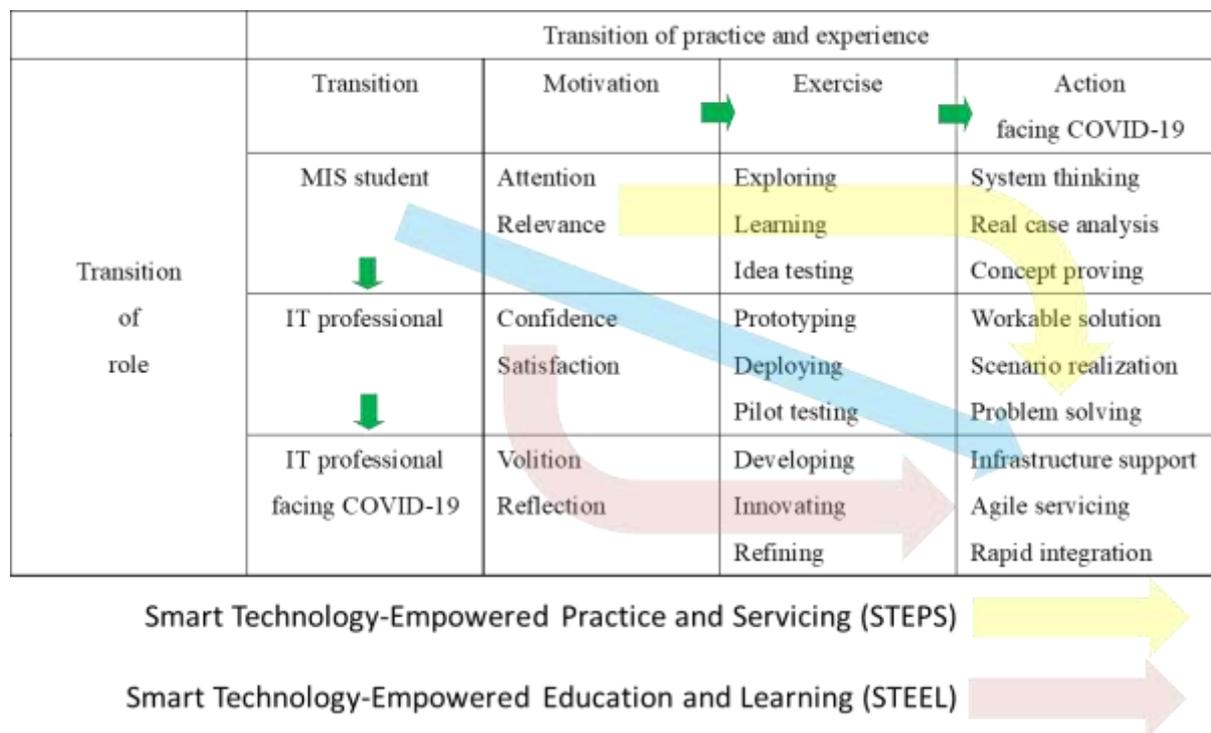
To summarize, the learning in MIS education and the practice of IT professionals can contribute to the realization of smart technology-empowered transition. Furthermore, the smart technology-empowered transition can mitigate the impacts of COVID-19 outbreaks and stimulate the cultivation of sustainable societies.

All of the participants expressed positive experiences about distance education and digital library, despite some of them being forced to use these technologies because of the COVID-19 outbreak. Learning in the clouds is a popular trend of continuous learning. Smart technology-empowered learning enables the generation of adaptable content of education (Marinova *et al.*, 2017). Therefore, learning and education using smart technologies are critical for MIS education since these topics highlight the two equally important facets of MIS education: learning for smart technologies and learning by smart technologies.

Furthermore, as the other industries are using smart technologies and integrated solutions provided by IT professionals to upgrade and evolve, the industry of IT professionals itself will also need to keep up and take the lead. By following the advocacy of Industry 4.0 for the manufacturing industry, the information service industry can also think of the vision and action plan of “Information Service 4.0” with the empowerment of smart technologies. “Smart technology-empowered information service” and “information service for smart applications” are thus a legitimate ambidextrous development strategy for IT professionals. With a substantial MIS education as a foundation and sustained progress with smart technologies, IT professionals can continue to play the indispensable supportive role for the world.

## Recommendations

This study reported meaningful implications regarding MIS students' perceptions of MIS education, IT professionals, and the COVID-19 outbreak. However, the validity of an argument cannot be firmly established on the basis of a single qualitative study. Further studies on this topic with various research methods and participants are recommended. Such research will help accumulate more empirical evidence for assessing and validating the propositions of this study.



Source: This study.

Figure 3: Facilitating the transition.

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## **Sustainable Smart Transportation System: Through the Lens of a Smart City in an Emerging Country**

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### **ABSTRACT**

Environmental and social sustainability continue to challenge urban development agendas, especially in emerging markets. Past literature on the topic of smart, sustainable cities has focused relatively less on developing countries – however, during the transient phase, such economies undergo several stages of development which this paper endeavors to investigate. The goal is to define key dimensions essential for evolving existing urban sites into a sustainable ecosystem. In this context, this study puts forward a framework consisting of five pillars: Scalability, Connection, Availability, Productivity, and Environment (SCAPE) to guide the implementation of sustainable cities in developing and tropical countries.

*Keywords:* Smart city, sustainable development, Malaysia.

### **INTRODUCTION**

Over the past decades, rapid economic development and migration of the population in search of better economic opportunities have led to the intensification of urbanization. This has led to the sprawling of urban townships, including ‘urban-ghettos’ globally. Urban townships and cities consume about 70% of the world’s resources and are key contributors to carbon emissions due to unsustainable energy use and poor development planning (Bibri & Krogstie, 2017).

Legacy transportation systems such as motorways and railways are still prevalent, especially in many of the emerging countries. Many of the cities have seen a surge in population due to economic migrants from rural localities, which have put pressure on existing infrastructure. Meanwhile, the dated transit services and facilities in these cities are also in urgent need of refurbishment. Lack of reliable, safe, and cost-effective transportation services are common deterrents that ultimately lead to the reliance of the urban population on personal motor vehicles.

As a response to the challenge of urban viability, the concept of smart, sustainable cities has been a key thrust in the United Nations Sustainable Development Goals (SDGs)- Goal 3 on ‘Good Health and Wellbeing’ and Goal 11 on ‘Sustainable Cities and Communities, that are two principal considerations directly linked to new urban development practices (United Nations, 2015). This global call-to-action provides an impetus for local policymakers and administrators to formalize the transition of legacy municipalities into smart, sustainable, and commutable cities.

Extant literature has largely focused on smart cities in developed countries, with limited empirical research from the developing countries (Walravens *et al.*, 2019; Larasati *et al.*, 2018). One of the research gaps that has been raised is the lack of coverage on the design and performance of smart cities conceived in emerging markets. This study investigates the evolution of brownfield developments toward sustainable urban transportation ecosystems, as well as the unique challenges/issues arising from such transitions.

The case study employed in this report concerns Sunway City Kuala Lumpur (SCKL) in Malaysia. Sunway City is a medium-sized township with a population of 200,000 residents (Sunway Group, 2020), developed from reclaimed quarry land in the 1980s, and has progressed from a low-to-medium-density residential cluster into a smart city. Sunway City’s private-sector-led development and administration have allowed its various transport sustainability programs to be mobilized quickly, though on a self-contained scale. These provided a research opportunity to assess both the adoption behavior as well as the performance

of key initiatives conceived in such a context. The specific initiatives investigated are the electric Bus Rapid Transit (BRT) system, elevated canopy walkway, and the smart parking system employing automation and sensor technology.

## LITERATURE REVIEW

There is extant literature on the attributes of a smart city and sustainable transportation (Bibri & Krogstie, 2017). Towards this end, many studies have assessed the smartness of the transportation systems (Garau, Masala, & Pinna 2016), sustainable urban mobility (Torrise *et al.*, 2020), environment (Nikitas *et al.*, 2021), and quality of life (Lionjanga & Venter, 2018). In this context, compared to the traditional urban bus, BRT has contributed to the transformation of urban transport by providing higher quality service in terms of better reliability, reduction of travel and waiting times, and improved user experience (Diaz *et al.*, 2004; Nadeem *et al.*, 2021). The implementation of BRT also reduced the emissions of air pollutants in the city (Bel & Holst, 2018).

Elevated canopy walkways, aside from facilitating movements, also protect pedestrians from air and noise pollutions (King *et al.*, 2016) and bad weather conditions (Yang, Qian, & Zhao, 2016). The elevated walkways have also been appropriated as an observation deck and a safe space for using the phone and chatting (Wang, Siu, & Wong, 2016).

The smart parking system established in San Francisco was able to reduce congestion (Krishnamurthy & Ngo, 2020). A similar system also reduced parking cruising by about 50% (Millard-Ball, Weinberger, & Hampshire, 2014). These studies highlighted that smart parking reduced parking congestion as vehicles cruising to look for available parking spots is one of the components of congestion. Apart from congestion, time is wasted, and circling for a parking lot burns fuel and increases carbon emissions.

In this study, five key pillars for a sustainable smart city have been identified based on the dimensions of sustainability encompassing environmental, economic, and social. The five pillars are Scalability, Connection, Availability, Productivity, and Environment (SCAPE) and are discussed below.

These smart city “SCAPE” dimensions are meant to provide a standardized qualitative metric to accommodate all developmental initiatives. Naturally, each undertaking will have its own emphases - targeted initiatives focused on a pinpoint resolution may contribute to one particular dimension; others may be enablers designed to facilitate interaction and synergies between two or more dimensions.

### **Pillar 1: Scalability**

Scalability implies the city’s ability to provide good quality service with increasing demand for facilities. A city must be consciously designed to accommodate high growth potential over a long-term period without affecting its quality of service. Minimizing friction arising from the introduction of new inhabitants and activities is essential and is often reflected through modularity in building, infrastructure, and spatial planning/design. Modern developments employ mixed-use zoning and spatial spheres demarcated by hybrid roles (residential, industrial, commercial, entertainment, institutional) and incorporate low-rigidity designs that can be more easily enhanced in the future.

### **Pillar 2: Connection**

Every social and commercial activity taking place in a city relies on the interaction between its inhabitants. A city’s design/administration will either encourage or hinder specific human interactions. Considerations here encompass the physical aspects of the city-spatial and service accessibility and the non-physical -digital infrastructure, policies, and legislation. Managing these factors well is essential to promoting communal collaboration, transparency, and bonding.

### **Pillar 3: Availability**

The livability of a city often correlates with the presence of more diverse facilities and services to benefit its inhabitants. Presence and resilience are the fundamental standards for gauging performance. While disruptions are inevitable over the course of a city’s lifespan, measures must be taken to ensure the long-term standard of living remains within acceptable bounds. The enforcement of well-defined policies should be complemented by redundancy in design to allow the usability of a city’s features to be rapidly restored from adverse events.

### **Pillar 4: Productivity**

By employing the right infrastructure, services, and policies, the city should allow individual and institutional inhabitants to pursue value-generating activities more efficiently. Such facilities provide a “leverage” for users to create and consume goods/services with minimal hindrances. The nature and cost of utilizing such facilities are major indicators of Productivity. Managing both facets well allows a city to have a competitive advantage to encourage new activities and long-term growth.

### **Pillar 5: Environment**

The interaction between humans to their surroundings is another crucial dimension in a city’s livability and the quality of life of the people. Comfort, aesthetics, and quality of nature are key indicators of a city’s performance and sustainability. More modern cities employ novel means of neutralizing their resource and waste footprints through passive systems such as sustainable materials and natural heating/cooling or active systems such as resource cycling and waste treatment. To be a truly sustainable city, reducing the burden of environmental impact through air pollution from vehicles on our natural ecosystems is important.

## METHODOLOGY

This study employed a purposive sampling with a total of 50 respondents split across 16 online focus group sessions to gauge the perception on the current state of the three local, sustainable transport systems, namely, the Bus Rapid Transit (BRT), Elevated Canopy walk (ECW) and Sunway smart parking (SSP). Respondents are a combination of residents, students, and working adults at Sunway City Kuala Lumpur.

All respondents are at least high school graduates, with 48% of them having received tertiary education (diploma or higher). 20% of respondents are local to Sunway City, while the remaining 80% are regular intercity commuters. Each interview lasts for 60-90 minutes, posing open-ended questions on the perceived strengths and weaknesses of each commute system and incentivizing factors that would encourage greater usage.

Positive and negative sentiments were assigned a score of +1 or -1 and were mapped to the corresponding SCAPE dimension. The average score for each dimension would thus represent an aggregate sentiment/perception on each transport mode.

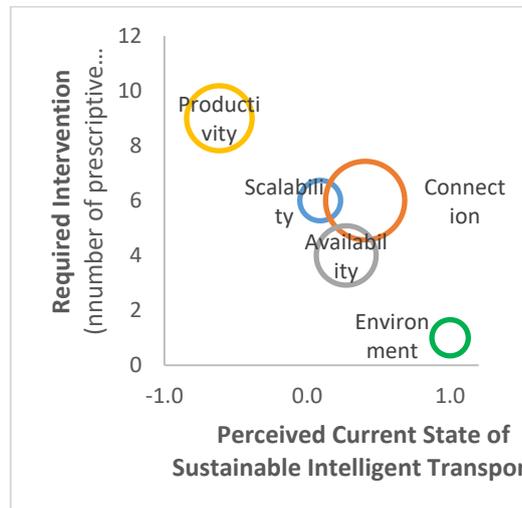
## DISCUSSION

This study synthesises the sentiments of the respondents, and the scored excerpts are plotted into three charts indicating public perception on the three transit systems, namely the electric Bus Rapid Transit (BRT) system, elevated canopy walkway, and the smart parking system. Each chart is further segmented into the five SCAPE dimensions, thereby providing some indication of prevalent opinions concerning a particular service. The size of bubbles in each chart indicates the number of unique respondent inputs on a particular topic of discussion. Tables I, II, and III provide deeper summarized interpretations of the interview sessions.

### A. Sunway City Bus Rapid Transit (BRT)

**Current situation:** Respondents most actively commented on the Connection implications of service. While coverage and security have been considered adequate, the maintenance of stations and availability of information (e.g., maps, seasonal pricing) can be improved (see Figure1).

**Future outlook:** The strongest prescriptive feedback relates to the Productivity dimension, specifically on the higher-than-average fares charged by the BRT service relative to the distance traveled. To attract more BRT users from the lower-income strata, targeted incentives or subsidies for this group may be necessary. While most respondents compare this ratio to that of other rail services offered in the adjoining cities, it is worth noting that the service quality offered is not equal (see Table 1).



Source: This study.

Figure 1: Sunway city bus rapid transit (BRT)

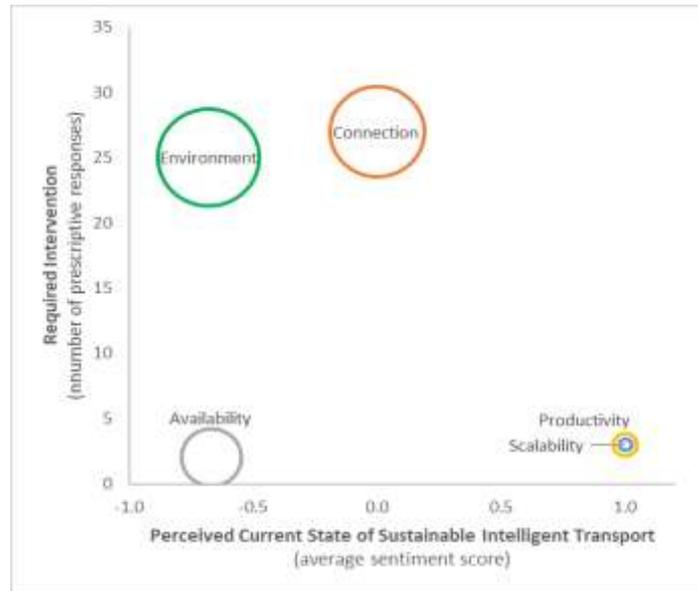
Table 1: Sunway city bus rapid transit (BRT)

Dimension	Current Perception		Proposed Improvements	
	Score	Strengths		Areas for Improvement
Scalability	+0.091	A modal shift from private to public transport facilitated by making public transport more attractive with a comprehensive plan that facilitates intermodal integration without compromising its service quality.	Increase size of bus fleet to accommodate larger, more frequent commuter throughput. Application for transit pass incentives is rather complex and time-consuming.	Improve fleet management to increase frequency of trips between hotspots during peak hours. Simplify and streamline the transit application process.
Connection	+0.450	Service coverage over key city hubs has significantly improved willingness to adopt. Station staff and patrolling guards confer a sense of safety and security to BRT users.	There is a need to educate potential commuters on incentives to offset cost of service. Faulty escalators and lifts at some stations diminish accessibility.	Use digital platforms to provide clear messages on the available incentives for alternative commuting. Introduce more stops in closer proximity to newer high-density locales within the city.
Availability	+0.273	Transit services offered by BRT have been consistently satisfactory in terms of punctuality, especially when compared to other rail lines. Overall comfort and convenience of each ride experience has been favorable, though this noticeably diminishes during peak hours.	Low turnaround for restoring faulty station equipment such as lifts and escalators; outdoor, exposed ones are especially prone to failure. BRT shuttles are often overcrowded during peak hours; some recommend skipping stops to overcome capacity constraints.	Increase size of bus fleet to accommodate larger, more frequent commuter throughput.
Productivity	-0.615	New monthly passes have significantly benefited regular users; due to BRT's high cost-per-ride, fixed payment structures provide a perceivable benefit to users. Student pricing incentives have benefited the communities of numerous local campuses; some hope for similar programs to be extended to other user communities (like office workers).	High cost of service remains a significant barrier to adoption, especially for irregular commuters. Locals who use public transport are typically price-sensitive due to their income/wealth profiles, and could not justify daily BRT use. Comparison of BRT's price-per-distance-travelled to other transit services enforces negative perception on cost.	Reduce price-per-distance of BRT fares to more closely align to other public rail services. Promote awareness of discounted passes and pricing campaigns among potential commuters through infostructure channels. Have commuter incentive programs to change commuter behavior (i.e. a mindset change)
Environment	+1.000	Reduction of reliance of personal vehicles of intracity and intercity commute, especially over longer distances, has reduced the environmental cost travel.	-	Continue to ensure environment is protected, increase number of bus fleets and incentivize commuters to use sustainable transport. Introduce vertical garden using the physical structures available

**B. Sunway City Elevated Canopy Walk**

**Current situation:** Respondents most actively commented on the *Environment* impact of the facility, closely followed by *Connection*. Overall, most users agree that protection against extreme weather conditions (often experienced in Malaysia’s tropical climate) can be improved further. Additionally, the linear layout makes traversal between specific locations challenging on foot, given the tropical climate in Malaysia. To encourage wider use of the infrastructure, especially among females, some respondents commented that improving the existing lighting during off-peak patrols will encourage high usage (see Figure 2).

**Future outlook:** The strongest prescriptive feedback relates to the *Connection* and *Environment* dimensions. Extended awnings, temperature controls, and enforced patrol frequency are the main improvements that respondents wish to see be implemented in the near future (see Table 2).



Source: This study.

Figure 2: Sunway city elevated canopy walk

Table 2: Sunway city canopy walk

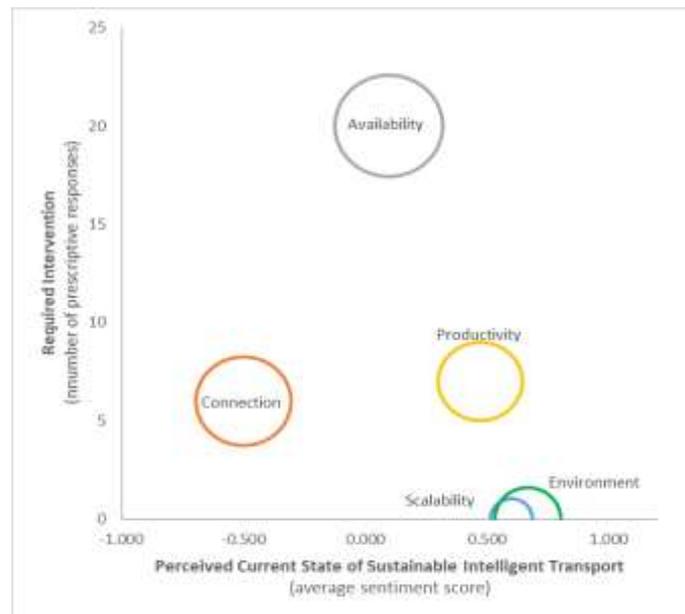
Dimension	Current Perception			Proposed Improvements by respondents
	Score	Positives	Negatives	
Scalability	+1.000	Allows intercity commuters to access key locales via mass transit system alone.	-	-
Connection	0.000	Good coverage of frequently visited hotspots, especially between campuses and commercial hubs. Safety features like panic buttons, CCTV, and guard patrols are present (but interspersed).	Reduce usability due to linear layout of footpaths requiring users to traverse large distances between specific destinations. Some major residential hotspots and campuses are too far away for practical, regular use of the Canopy Walk. Need more signage for easy navigation. Occasional low staff discipline among patrolling guards. Poor lighting. Flooring material prone to slippage, especially when wet.	Introduce shortcuts to bridge across distant a lighting points, and transform the current looped layout into a latticed one. Improve connectivity of Canopy Walk to residences and student hostels. Introduce and enforce better accountability KPIs for guard performance. Increase and standardize presence of patrols across the entirety of the Canopy Walk network
Availability	-0.667	Provides a means for pedestrians to move at a safe distance from busy roadways.	Pathways tend to become overcrowded in popular spots. Some areas are prone to leakage and drainage issues during rainfall.	Widen existing pathways near hotspots, or introduce parallel, alternative routes.

Productivity	+1.000	Provides a cost-free means of traversal between (a limited number of) high-density locales.	-	Introduce advertisements and informational banners across the Canopy Walk to increase utility.
Environment	-0.688	Provides scenic access to recreational/leisure hotspots and urban greenery. Provides (limited) protection from elements.	Common extreme weather (rainfall and heatwave) renders certain footpaths not conducive to use due to inadequate shielding/sheltering against elements.	Extend static roofing or walls to protect against extreme weather. Introduce climate control/air-conditioning at enclosed areas of the walkway. Introduce sensor-triggered weather screens that extend/retract/enclose based on prevailing weather. Introduce vertical garden

**C. Sunway City Smart Parking**

**Current situation:** Respondents most actively commented on the *Availability* dimension followed by *Connection*. Ticketless admission and payments have been agreed to be a significant boost to convenience, despite introducing some new technological barriers of entry and potential points of failure (see Figure 3).

**Future outlook:** The strongest prescriptive feedback relates to *Availability*. Respondents wish for better redundancies in the system by retaining some capacity for traditional ticketing and cash payments in case the smart parking features become unavailable/inaccessible. Some also noted intelligent navigation and capacity management to direct drivers quickly to allotted bays as an avenue for future improvement (see Table 3). Additionally, traffic feeds on surrounding motorways are also desirable. Key exits leading to specific thoroughfares can be color-coded to denote ongoing congestion, allowing users to preplan their exit route in the parking bays itself, allowing the smart parking infrastructure itself to help regulate vehicle on-boarding across the surrounding area.



Source: This study.

Figure 3: Sunway City Smart Parking

Table 3: Sunway city smart parking

Dimension	Current Perception			Proposed Improvements
	Score	Strengths	Areas for Improvement	
Scalability	+0.600	On-demand ticketing resolution via remote QR scanning reduces congestion at traditional booths.	The fundamental under-capacity of parking bays for peak volumes remains unresolved; ticketing digitalization simply shifts congestion from one point (physicals gates) to another	

			(inside the carpark, as drivers search for vacant bays).	
Connection	-0.500	Excellent coverage of payment QR codes throughout commercial venues allow for convenient, on-demand ticketing resolution. Elimination of physical queuing allows for minimal exposure or contact amid Covid-19 pandemic.	Unclear signage makes navigation in and out of parking bays difficult. Privacy and security concerns arise from disclosing linked personal financial details for electronic payments. No real-time indication of parking bay vacancy via sensors connected to Sunway lifestyle app results in drivers having to search for spots.	Integrate parking bay location intelligence infrastructure with Sunway lifestyle app to direct drivers to preallotted parking bays.
Availability	-0.667	Alternative means of payment eliminates the risk of misplacing physical tickets. Alternative means of payment reduce reliance of physical infrastructure, and their implicit bottlenecks.	Poor staff education during transition period to digital ticketing resulted in encounters demanding physical proof of payment.	Increase number of electronic payment options supported. Retain ability to receive traditional cash payments in case of system downtime. Retain capacity to receive traditional cash payments in proportion to senior citizen visitors who are more resistant to change.
Productivity	+1.000	Automated license plate scanning improves vehicle throughput and user experience. Digitalized payment options are integrated with mainstream eWallets and payment instruments.	License plate scanners can impair the smart parking system if they malfunction. Reliability of electronic payment options is inconsistent; system downtimes and poor network coverage in the car park sometimes disrupt service.	Implement temporary parking discounts to increase user traffic and by extension, encourage self-learning of new digital parking system.
Environment	-0.688	Paperless ticketing system reduces wastage.	Encourages increased use of personal vehicles	

### CONCLUSION

The performance of Sunway City's sustainable transport models within the metrics of Scalability, Connection, Availability, Productivity and Environment (SCAPE) has uncovered a combination of *technical*, *behavioral*, and *physical* strengths and areas of improvement to transform the city into a model for 'smart and sustainable green city' in the emerging world, aligned to the United Nations Sustainable Development Goals. A sound smart transportation system will lead to significant economic spillover benefits (Pradhan *et al.*, 2021).

Results from this study have important implications for cities in emerging countries in transforming their transportation systems to meet the needs of a digitally connected society. The study shows that recovery time objectives for addressing infrastructure degradation (for example, machinery repair and weatherproofing) need to be well-defined and are perceivably reliable enough to become the primary means of travel.

Behavior management is crucial in ensuring the critical adoption of sustainable transport alternatives. Targeted pricing incentives for key user communities (students, local white-collar workers) appear to be the best means of driving growth in utilization volumes. Another unexpected barrier is the resistance toward technological adoption, demonstrated by the lack of confidence of some users toward electronic payments. Hence, improved infrastructure frameworks for educating users cannot be overlooked when introducing major technological shifts to the status quo.

This study has provided the *SCAPE* framework to be validated as an overarching guideline for contextualizing developmental priorities in sustainable urban planning. Industry practitioners and policymakers should leverage these findings to systematically identify, test, and refine sustainability KPIs within the aforementioned five dimensions.

In summary, the *SCAPE* framework can be a tool to 'stress-test' the state of development of the transportation system in meeting the needs of a digitally connected society. It will provide valuable information and insights to design a smart infrastructure that will encourage seamless integration of the public transportation system and ensure it is a preferred choice of transportation for the population. This will have a significant positive spillover impact on the sustainable socioeconomic development agenda of

cities in emerging countries.

#### ACKNOWLEDGMENT

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## Technology-Enabled Innovations to Combat Covid-19 Pandemic: A Case Study between Thailand and Taiwan

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### ABSTRACT

The COVID-19 pandemic has been disrupting people's lives for the past two years. Countries worldwide tried to control the number of infections with new and enhanced information technology with varying results. This case study compares the information technologies used to control and combat the COVID-19 pandemic in Thailand and Taiwan. This study aims to identify the contributing factors that make information technology become more effective in controlling the COVID-19 pandemic. This data was gathered retrospectively from December 2019 to August 2021 from 46 subjects in both countries. The results have shown that the category of technology released was inconsistent with entering the stage of transmission of the COVID-19 pandemic. In addition, policy factors such as the rigor of policy, credibility of government or related agencies, including social factors such as the public engagement, communication technology, and the diffusion of innovation, play a key role in enabling the technology to be more efficient for the control of COVID-19 pandemic.

*Keywords:* Coronavirus, Covid-19, pandemic, digital governance, public trust, communication, technology

### INTRODUCTION

The COVID-19 pandemic started in late 2019 and still continues into 2021. To deal with the COVID-19 pandemic, governments worldwide have leveraged different types of Information technologies to help control and combat the pandemic in many countries (Ye *et al.*, 2020). Thailand is one of the countries that has responded quickly and effectively to the Covid-19 pandemic during Phase I – Phase III, between March 2020 – March 2021. Thailand also has strong public health systems to support general healthcare during that phase. During the period between 30 January 2020 to 30 June 2020, Thailand had only 3,171 confirmed cases and 58 deaths from COVID-19 infection (WHO, 2020). Thailand was recognized by the WHO for good handling and response to the COVID-19 pandemic in the early phase (Royal Thai Embassy Washington D.C., n.d.). Thailand has introduced mobile applications such as ThaiChana (Thais- Must-Win) to be used for tracking and controlling the spread of COVID-19 infection in a timely manner. Subsequently, different mobile applications were created and used by Thai citizens such as Mohprompt (Doctor Is Ready), Thai Ruamjai (Thais Together), and Rao-Chana (We Will Win) are some of the leading mobile applications that emerged from both government and private sectors.

Another country that has been recognized for successfully controlling the COVID-19 pandemic is Taiwan. Taiwan was the first country to provide information to the World Health Organization about the infection that can spread from person to person, and the Taiwan government had authorities performing onboard inspections of passengers on direct flights from Wuhan City immediately. For a period of approximately five months, after the World Health Organization announced the pandemic situation on January 30, 2020, until July 1, 2020, Taiwan has only 447 confirmed cases and only seven deaths (Cumulative total of 447 COVID-19 Cases Confirmed in Taiwan; 438 Patients Released from Isolation) (Taiwan Centers for Disease Control, n.d.-a). Taiwan leveraged its national health insurance database and integrated it with its immigration and customs database to begin the creation of big data for analytics; it generated real-time alerts during a clinical visit based on travel history and clinical symptoms to aid case identification.

In addition, the Taiwanese government has also used telecommunication systems to send immigration confirmation documents in the form of SMS, which will facilitate immigration for those possible people with a low risk of infection (Wang, & Brook, 2020). The technologies adopted by each country have produced many benefits; the question is, "What technologies are the most effective in controlling a health crisis such as the COVID-19 pandemic?" The two countries mentioned above are both recognized as being able to respond well to the situation. In addition to its strength in the healthcare system, both countries have rapidly developed technology for more effective epidemic control policies.

For this research, the researcher's intention is to conduct comparative case studies and determine the similarities and differences of Thailand and Taiwan's information technology to combat the COVID-19 pandemic.

The research objectives are to find lessons learned from both countries in terms of how they use different types of information technologies to respond to the COVID-19 pandemic. Given the main purposes, two key research questions are as follows:

1. Which information technology that Thailand and Taiwan utilize in controlling the spread of the COVID-19 pandemic?
2. Which factors for the technology need to be focused on in the disease control situation?

To further clarify the questions, this research will approach the problems by:

1. Identifying the severity of the epidemic situation using criteria based on the Definition of the categories for transmission pattern from the World Health Organization.
2. Identifying the type of information technology framework based on relevant previous research.

## LITERATURE REVIEW

### Information Technology for COVID-19 Pandemic

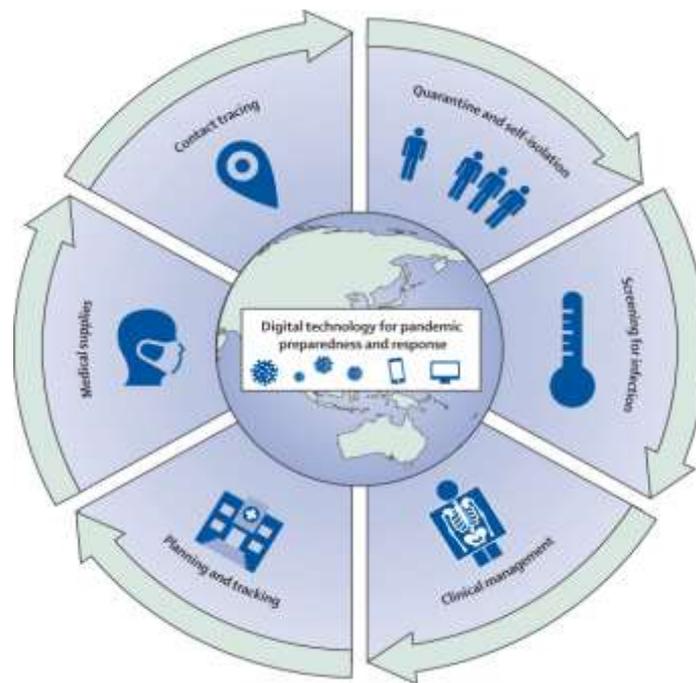
Epidemic Control and Prevention Organization describe the severity level of infection according to the epidemiological principle of 7 types (1) Endemic or local epidemic for diseases that populate within a geographic area but are not violent. (2) **Sporadic** refers to a disease that occurs intermittently and irregularly. (3) **Hyperendemic** refers to persistent, high levels of disease occurrence. (4) **Epidemics** refer to an epidemic with an increasing number of cases but normally expected in that population in that area. (5) **Outbreaks** refer to the same definition as the epidemic but are often used for a more limited geographic area. (6) **Clusters** refers to increases in clusters over a period of time, according to the place and time of suspicion being greater than the number expected. (7) **Pandemic** refers to an epidemic that has spread over several countries or continents, usually affecting a large number of people (Centers for Disease Control and Prevention, 2012) World Health Organization declared a COVID-19 Pandemic on 11 March 2020 and divided the categories for transmission for Coronavirus (Covid-19) into four stages according to the level of spread in each area or country as follows (see Table 1).

Table 1: Definition of the categories for transmission pattern

Category name	Definition
No (active) cases	No new cases were detected for at least 28 days. This implies a near-zero risk of infection.
Imported / Sporadic cases	Cases detected in the past 14 days are all imported or sporadic (e.g., laboratory-acquired or zoonotic), all linked to imported/sporadic cases, and imply a minimal risk of infection for the general population.
Clusters of cases	Cases detected in the past 14 days are predominantly limited to well-defined clusters that are not directly linked to imported cases but are all linked by time, geographic location, and common exposures. It is assumed that there are a number of unidentified cases in the area. This implies a low risk of infection to others in the wider community if exposure to these clusters is avoided.
Community transmission – level 1- level 4 (CT1-CT4)	<b>Low incidence</b> (CT1) of locally acquired widely dispersed cases detected in the past 14 days are not linked to specific clusters; transmission may be focused in certain population sub-groups. Low risk of infection for the general population. <b>Moderate incidence</b> (CT2) refers to the Moderate risk of infection for the general population. <b>A high incidence</b> (CT3) refers to a High risk of infection for the general population. <b>A very high incidence</b> (CT4) refers to a Very high risk of infection for the general population.

Source: Wenger, Halperin, and Ziga (2009)

Social distancing is a key success to curb the epidemic, but the use of other policies, such as space restrictions, isolation, and quarantine further, enhance the effectiveness of the policy to control the spread of the disease (Chen *et al.*, 2020) and creating the digital age (Guy, 2019) The research compiled the application data generated for preparing and responding to an epidemic situation and categorized them into six categories (1) Planning and tracking (2) Medical Supplies (3) Screening for infection (4) Contact tracing (5) Quarantine and self-isolation (6) Clinical management (Whitelaw, Mamas, Topol, & Van Spall, 2020). This framework showed that the adoption of technology in conjunction with the epidemic policy might contribute to lower rates of infection and death rates. During the severe epidemic period, it is necessary to accelerate the adoption of technology as soon as possible. To facilitate front-line operations, planning, surveillance, testing, contact tracing, quarantine, and clinical management can be carried out on larger and more intensive scales, as shown in Figure 1.



Source: Whitelaw et al. (2020)

Figure 1: Digital technology as a tool for pandemic preparedness and response

### The Diffusion of Innovations & Privacy Communication Technology

Information technology is increasingly becoming a part of everyday life (Kirk, Ractham, & Abrahams, 2016). The diffusion of technology so that it is accessible to all has become an important aspect of technology adoption along with national policy (Tim et al., 2013). The diffusion of innovations has been explained by categorizing the entire society into five categories: (1) **Inventors**, the first people to initiate new innovations, (2) **Early Adopters**, people who are able to accept new innovations quickly (3) **Early Majority**, people who must allow innovation to demonstrate usefulness and efficiency before adoption can occur, (4) **Late Majority**, this group tends to have questions about the usage and wait until the majority of people find success in using it before they begin to accept the use, and (5) **Laggards**, people who tend to be strict in their traditional practices, making it difficult to accept change (Rogers, 1962). Even though people can accept the use of new technology, there are other negative factors, besides the usefulness of the technology, that are significant for people to be wary of it (Firpo et al., 2009). For example, users are increasingly concerned about security issues and the accidental use of consumer information provided. In terms of privacy, some researchers view trust as a mediating variable between privacy concerns and disclosure (Metzger, 2004; Xu et al., 2005). Building trust is more effective than trying to reduce consumer concerns.

### Communication Technology

During the Covid-19 epidemic situation, social media has been the most effective news channel for broadcasting and publicizing medical knowledge (McGowan et al., 2012). Social media has been used to bridge the gap between government organizations and the general public; therefore, the government's social media has been used as a tool to help make intended goals more effective (Bryer & Zavattaro, 2011; Mergel, 2013). Moreover, the public view of the media is more embodiment than other public communication. The public media might be even more inductive that information dissemination can help control this epidemic (Lipsitch et al., 2020). Early-stage emergency adoption situations of people lead to enthusiasm for people's participation in society, both the private sector and education sector (WHO (Thailand), 2020). Emerging of social media and restrictions policy during the epidemic situation clearly showed the help from the public in society. The Thai community have expressed through public engagement that they help each other through online channels by doing good deeds, such as making donations, helping to share or forward salutary information (Wiederhold, 2020)

### Trust & Governance & Public Engagement

Trust in information and willingness to trust others, as moderated by personal attitudes, can be a contributing factor or a catalyst for change, such as civic participation (Tang et al., 2012). Gaining public confidence and trust in an organization or institution is tendentious to achieve the goal of engagement, particularly in decision-making situations. The role of trust in a civic context seems to be most salient where the individual is assessing the fairness of a decision outcome or decision-making process (Gordon et al., 2013; Terwel et al., 2010). The research of Hu, Tang, and Smith (2008) shows that comprehensive government regulations gain consumer trust, but rules might not be appropriate for a particular society nor in certain circumstances.

The COVID-19 epidemic situation illustrates one of the country's dominant concepts that constitute Digital Governance, which has evolved from network governance, including contemporary considerations of governance, which helps to solve social,

government, and personal problems (Kitchin, 2014). These concepts change the people's roles into active citizens who can communicate with others and their government through the use of information technology. Digital governance strategies or approaches are becoming the cornerstone of organizations and institutions, transcending traditional perspectives and attitudes

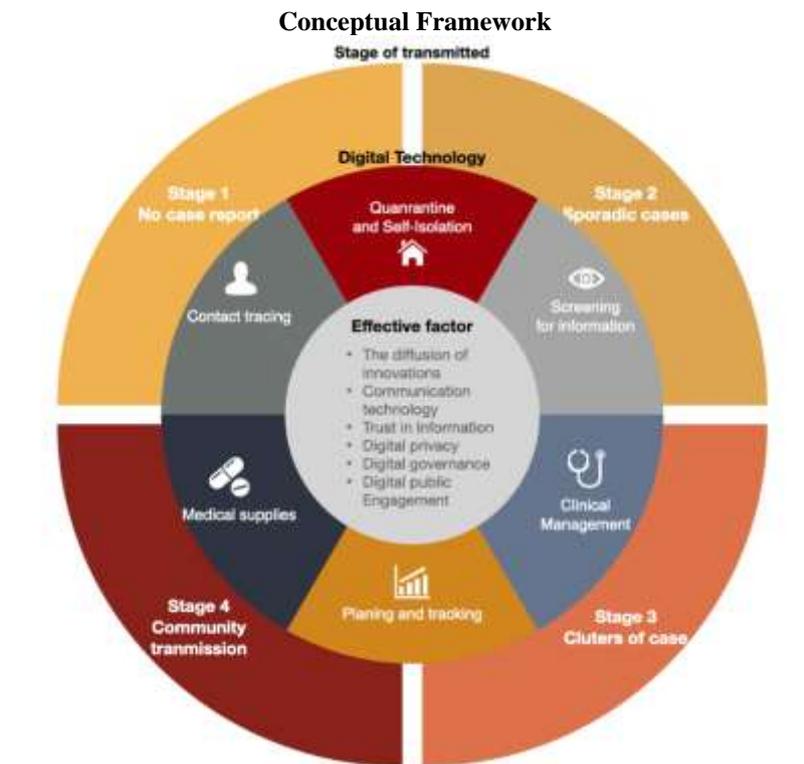


Figure 2: Conceptual Framework

This research has extended the model to create a clearer picture of technology development by synthesizing the previous research as described in the literature review. The conceptual framework combined Stage of Transmitted with Digital technology as a tool for pandemic preparedness and response (Whitelaw et al., 2020). Stage of Transmitted, according to WHO documents, outbreaks are categorized into four levels: 1) No cases reported 2) Sporadic cases refers to entering a phase where more than one infection has been detected or is an infected case caused by traveling from outside the area (imported case) or a specific area detected. 3) Clusters of cases refers to infection detected in a specific group spread over a period of time or only in a certain area or region 4) Community transmission refers to locally acquired widely dispersed cases with evidence by the inability to relate confirmed cases through chains of transmission for a large number of cases, or by increasing positive tests through sentinel samples (routine systematic testing of respiratory samples from established laboratories). Transmission classification is based on WHO analysis of available official data (may be subject to reclassification as additional data become available). Not all locations within a given country/territory/area are equally affected. Areas experiencing multiple types of transmission are classified in the highest category.

By combining this knowledge with the research (Whitelaw et al., 2020), criteria were used to classify the technologies used in the COVID-19 epidemic into six categories: 1) **Planning and Tracking** refers to technology with functionality for tracking disease and activity in real-time. 2) **Medical Supplies** refer to the technology used for the management of medical equipment especially necessary equipment for disease control, such as face masks, medicines, and alcohol sanitizer. 3) **Screening for information** refers to technology that has the function of screening and monitoring the symptoms of both individual and collective diseases. It can identify groups of people at risk for infection and track the spread of infection and quarantine. 4) **Contact tracing** refers to technology that has a function to track the information of people who were in contact with infected people. It involves searching for exposed persons for examination and tracking information on quarantine and further transmission of infection. 5) **Quarantine and self-isolation** refers to technology with the function of individualized symptom monitoring and quarantine monitoring 6) **Clinical management** refers to technology with the function of diagnosis, following and monitoring the treatment situation, assessing treatment outcomes, and providing virtual treatment care services.

To find the answers to the second research question, this research identified the effective factor in six factors that are expected to affect the effectiveness of pandemic control technologies, 1) The diffusion of innovation 2) Communication technology 3) Trust in information 4) Digital privacy 5) Digital governance 6) Digital public engagement and all of that can be summarized as shown in Figure 2.

## RESEARCH METHODOLOGY

### Data Collection

To find the answers to the questions, the qualitative method was selected to find results in this study via data collection of academic information from documents of government agencies or from related organizations, including information that was announced by the government and publication from reliable news agencies or publishers. The historical information was collated since the beginning of Coronavirus spreading. Data were collected from December 2020 to June 2021. The online survey and semi-structured interview were used to collect the data. Subjects were selected by purposive sampling solution (Palinkas *et al.*, 2013) as users' specification who lived in Thailand and Taiwan during the Covid-19 pandemic or stayed in that country for a period of at least 180 days. The total number of volunteers was 46, divided into two groups. There were 26 subjects who lived in Thailand and 20 subjects who lived in Taiwan. See Tables 2, 3, and 4.

Table 2: The number of volunteers who participated in the survey and interviews

Age	Thai	Taiwanese
18-24	1	1
25-35	18	12
36-44	3	3
45-55	1	1
56-60	1	1
>60+	2	2
Total	26	20

Table 3: Residential area of the volunteers who participated in the survey and interviews from Thailand

Residential area	Thailand
Bangkok	13
Bangkok metropolitan area	2
Eastern	1
Northeastern	3
Northern	4
Southern	3
Total	26

Table 4: Residential area of the volunteers who participated in the survey and interviews from Taiwan

Residential area	Taiwan
Taipei	13
Taichung	5
Others	2
Taipei	13
Total	20

Questions of the survey were similar between the two groups and followed a semi-structured interview format. There were face-to-face interviews, video call interviews, phone call interviews, and email questionnaires. All interviews and surveys were collected between July 2021 and August 2021, or 7 weeks, to explore the in-depth factors that supported or influenced the use of technology for controlling COVID-19 spreading.

### Case Study

This research gathered the data technology that supports the pandemic disease control from both private and government agencies during the period from December 2019 to June 2021 and identified the period of first release date technology matched with the stage of transmission, as defined by the World Health Organization, and categorized technology in 6 Category according to previous research. Technologies that have more than one function will be identified as both categories of technology, and technologies that cannot be identified in 6 functions would be added in other categories. The technology that emerged before the first case was announced, researchers would match in Stage 1. After the first case was detected, the situation entered Stage 2 or Sporadic case. Entering stage 3 was based on information from direct regulatory agencies such as CECC, CDC, or WHO.

Table 5: Technology of Thailand under the conceptual research framework.

Stage of transmitted	Categories of Technology	Name of technology
Stage 1 No cases reported	Screening for Information & Clinical Management	Doctor Near U (Klai Mua Moh)
Stage 3 Clusters of cases	Planning and Tracking	Away Covid-19
		Thailandplus for travelers
	Screening for Information	COVID-19 Tracker

		Thaisavethai
		Thai Stop COVID Plus
	Contact tracing	Thaichana
	Quarantine and self-isolation	AOT DIGITAL AIRPORTS
		Sydekick
	Clinical Management	Thai raum jai
		Mohprompt
	Medical supplies	MASK MAP THAI
	Screening for Information and Planning and Tracking	Mohchana
		Goo care
	Screening for Information and Clinical Management	Clicknic
	Screening for Information and Quarantine and self-isolation	DDC Care
	Screening for Information and Others (Source of information)	Card2u by Thaifight Covid
	Screening for Information and Medical supplies and Clinical Management and Other (Quarantine supplier)	Pedthaisupai

Thailand has announced the first detected case that entered Stage 2 or Sporadic case from 13 January 2021 to stage 3 on 28 February 2020 until the end of the data collection period of this research (August 2021) (Novel Coronavirus in Thailand, nd). Thailand has a total of 18 technologies to cope with the Covid-19 epidemic situation. This research data found that the technology available during Stage 1 (No cases reported) is an application Doctor Near U (Klai Mua Moh). There are 0 technologies in Stage 2 (Sporadic case). In Stage 3 (Local Transmitted), Thailand emerged with 17 technologies, including Away Covid-19, Thailandplus for travelers, COVID-19 Tracker, Thai Save Thai, Thai Stop COVID Plus, Thaichana, AOT AIRPORTS, sydekick, Thai raum jai, MohPrompt, MASK MAP THAI, MorChana, Clicknic, DDC Care, Card2u by Thaifight Covid, Goo care and Pedthai Suphai. See Table 5.

Table 6: Technology of Taiwan under the conceptual research framework.

Stage of transmitted	Categories of technology	Type of technology used
Stage 1 No cases reported	Contact tracing	Tracing
	Quarantine & Self-isolate	Digital Quarantine tracking system
	Planning and tracking & Screening for Information & Contact tracing	Big data analysis
	Clinical Management	National health insurance management
Stage 2 Sporadic cases	Quarantine & Self-isolate	Disease Containment Expert LINE Bot
	Clinical Management	V-Watch
	Medical supplies	Mask Map
	Other	Google Assistant Chatbot
Stage 3 Clusters of cases	Contact tracing	Taiwan Social Distance
		SMS for contact tracing

Taiwan announced their entering into Sporadic case as of 21 January 2020 (Taiwan Centers for Disease Control, n.d.-b) and entered Local transmission, stage 3, on 11 May 2021 until the end of the data collection period of this research (August 2021). Taiwan has a total of 10 technologies to cope with the Covid-19 epidemic situation. There are four technologies, namely Trace, Digital Quarantine tracking system, big data database system, and National health insurance. There are four technologies in Stage 2 (Sporadic case), namely Disease Containment Expert LINE Bot, vTaiwan, face mask map app, and Google Assistant Chatbot. There are two technologies in stage 3 (Local Transmitted), namely Taiwan Social Distance and SMS for contact tracing. See Table 6.

For example, Taiwan has devised several different mobile apps to help deal with the epidemic situation and to share this technology with other countries. According to Central Epidemic Command Center (CECC), for example, people in Taiwan can use a smartphone app to help the government's contact tracing effort; this is especially critical during stage 3. To increase the motive of the usage of mobile apps, users who access the contact tracing feature are eligible to participate in a lottery on the CDC's Facebook page for a chance to win a NT\$500 (US\$17.87) voucher with purchases made at designated supermarkets. More importantly, this app does not require typing in personal information because all the collected data is stored anonymously on the device, reducing the possibility of leakage of personal information.

Another example of how new technology can be helpful as an early warning system is an application called "The Taiwan Social Distance app." This app aims to prevent transmission of COVID-19 by notifying the users if they come within two meters from a confirmed case location that occurred less than two minutes ago. This has become extremely useful, especially during stage 3, when the pandemic cases are skyrocketing in early May 2021. Furthermore, this social distancing app applies Bluetooth technology

to automatically save distance records from the last 14 days and allows users to be informed when exposed to confirmed cases. It also meets the EU regulation on data protection and privacy, so neither the government nor the developer can gain access to the records, which increases the users' willingness to use new digital service technology.

## RESULTS AND DISCUSSION

The researchers collected data and compared the types of technologies from both Thailand and Taiwan by following the proposed conceptual framework. The information can be summarized as follows in Table 7.

Table 7: Comparison of technology of Thailand and Taiwan under the conceptual research framework.

Stage of transmitted	Similarity technology of Thailand and Taiwan	Difference technology	
		Thailand	Taiwan
Stage 1 No cases reported	Screening information Clinical Management		Planning and tracking
			Quarantine and self-isolation
			Contact tracing
Stage 2 Sporadic case			Quarantine & Self-isolate
			Clinical management
			Medical supplies
			Others
Stage 3 Local transmission	Contact tracing		Planning and tracking
			Screening information
			Quarantine and self-isolation
			Clinical management
			Medical supplies
			Others

### Stage 1

During the first stage of transmission, Stage 1, with No case reported, it was found that Thailand and Taiwan have similar technology in Screening Information and Clinical Management. Thailand has Doctor Near U (Klai Mue Moh). This is a collaboration between the Thai Health Promotion Foundation and the private agency was released in November 2019. Doctor Near U is a mobile application and serves as a virtual clinic where people can be diagnosed at their fingertips. Furthermore, users can request additional consultation from a doctor via chat. The main purpose of the Doctor Near U application is to provide people with free access to basic medical care. In addition, it includes features to diagnose and screen for early symptoms of the Covid-19 disease, which matches the technology in the Screening Information category and can provide nearby hospitals or specialist doctors to contact users for treatment in the next step, which classifies the technology of the Doctor Near U as Clinical Management as well.

In Taiwan, a national health insurance system has been developed over two decades and is now available in the application technology. Taiwan citizens can access the health insurance system from every hospital or healthcare service via a smart card. In addition, Taiwan has connected the database of the National Health Insurance System, immigration information, and telecommunications. Consequently, Taiwan can integrate a Huge Big Data database system, making it possible to assess for signs of disease in an apparently asymptomatic population with real-time monitoring of the spread of infection across locations. The Taiwanese government also connects existing databases with telecommunication systems and third-party application data for the use of tracing a history of infected people traveling to different places. It will detect people who visit the same location and period and, thus, send SMS to mobile phones to inform people directly (Jian *et al.*, 2020). Taiwan's big data systems covered categories of Screening Information, Planning and Tracking, and Contact tracing technologies. Furthermore, in the first stage, the difference in technology between Thailand and Taiwan is that Taiwan has planning and tracking, quarantine and self-isolation, and contact tracing technologies that are developed and available during this No case report phase.

### Stage 2

Sporadic cases, or the second stage of transmission, are all linked to imported/sporadic cases or a specific area detection. The obvious observation is that Thailand has no technology developed during this period while Taiwan has developed Quarantine & Self-isolate namely Disease Containment Expert LINE Bot that sends daily messages and monitors a person's health during home quarantine, and Clinical Management Namely V-Watch, which was developed to support public health messages for monitoring and tracking post-vaccination. This system provides appropriate medical advice and calculates the date of the second dose of vaccination, and sends a message for advance notification. Taiwan also has Mask Map, which is classified as Medical supplies technology to divide the quota for citizens purchasing face masks to prevent product domination. Another technology is Google Assistant Chatbot which is classified in the other types of technology. The purpose of the Google Assistant Chatbot is to provide information or answer questions on matters relating to the infection for the public.

Comparing the stage of transmission between Thailand and Taiwan, Thailand has stepped into the second stage, the Sporadic case, since 13 January 2021 and entered the third stage, Local transmission, on 28 February 2020, which took only 41 days. While Taiwan has stepped into the second stage, sporadic case, since 21 January 2021 and announced to enter the third stage,

local transmission, on 11 May 2021, that means Taiwan keep the number of infection cases in the second stage for one year three months and 21 days. For this reason, all four technologies can help to slow down the spread of the disease from sporadic cases to local transmission.

### Stage 3

Local transmission, the third of the transmission stage, locally acquired widely dispersed cases detected. The essential technology of disease control that Thailand and Taiwan similarly focus on is Contact Tracing. In this period, Taiwan has developed only two technologies, which all contact tracing technologies, including the Taiwan Social Distance application, notified users who had visited the same areas as confirmed case in the last 14 days. The other one is SMS for contact tracing or QR system for sending SMS messages to track the timeline by QR code scanning; then, the system will automatically sync into the messaging system and show the specifying code by shop location and sending the message out, with no fee charged and no internet needed besides elaborate tracking and thoroughly reaching the population. Like Thailand builder Thaichana platform, Contact tracing technology, one of 17 technologies developed in the third stage. Thai-Chana is available on both websites and applications to track people's timelines in shopping malls or shops by collecting check-in and check-out information with QR codes. Department of Disease Control Ministry of Health is solely authorized to access data tracking and quarantine.

The results of the volunteers, both the interviewee and the survey respondents, show that the most used technology in both Thailand and Taiwan is the Contact Tracing category. Among 26 users from Thailand, there were 20 users who use Thaichana technology, and among 20 users from Taiwan, there were 12 users who opted for SMS Tracking and eight users who opted for TAIWAN Social Distancing. The obvious observation, all three technologies developed and enabled similarly during the countries' local transmission stage. Taiwan users opted for technologies that emerged during Stage 2 by three technologies, like the following, Google Covid trackers seven users, Mask maps six users, Disease Containment Expert LINE Bot 1 User.

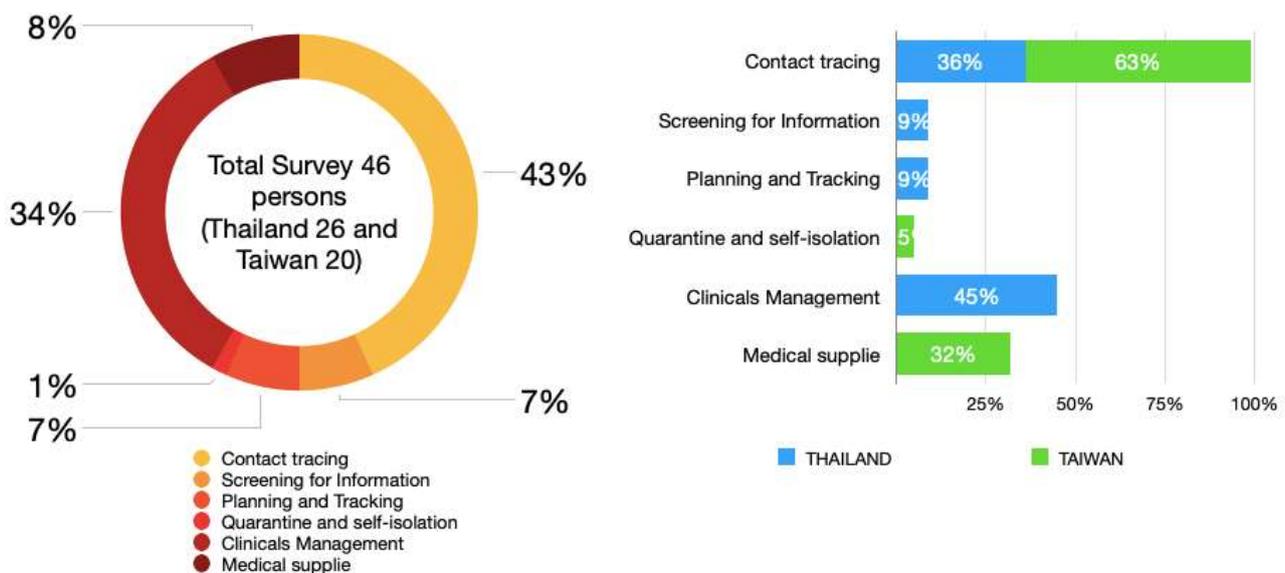


Figure 3: Usage of Covid-19 pandemic technology Survey

Through Analyzing responses from user groups in both countries, it was found that adoption technology is used for (1) Social and legal regulations, (2) Social responsibility, (3) Used applications (4) Needed Features. The reasons for refusal of using can be grouped into three main reasons: (1) Not having used the technology before, (2) No need for use (3) Not tech-savvy. The responses from the user group are consistent with Riemer, 2020 research which states that mandated enforcement makes people adopt tracing technology and efficiency for public health. See figure 3.

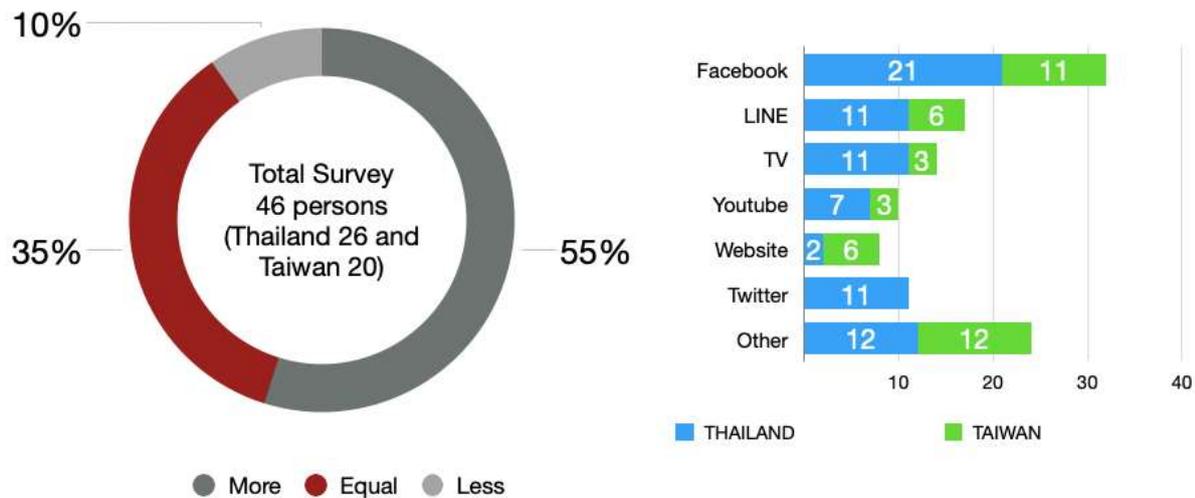


Figure 4: Communication technology of Covid-19 pandemic technology survey

To further delve into the behavior of technology usage in communication (Communication Technology & Society), it was found that more than 55% of users felt that they consume more information, such as the news from social media and all sources of information, during the epidemic situation than the preceding period of emerging infectious diseases. Only 35% responded that they were consuming the same amount of news (as a preceding period), and only 6% consumed less information than in the preceding period. In line with an academic document from the World Health Organization (WHO) titled Joint Intra-Action Review of the Public Health Response to COVID-19 in Thailand, it states that acceptance of the situation of people in society at an early-stage lead to enthusiasm for the participation from both groups of people in society and in the private sector. The most popular communication channel used by volunteers in both countries is Facebook, with 33 users, whereas 17 people use LINE. See figure 4.

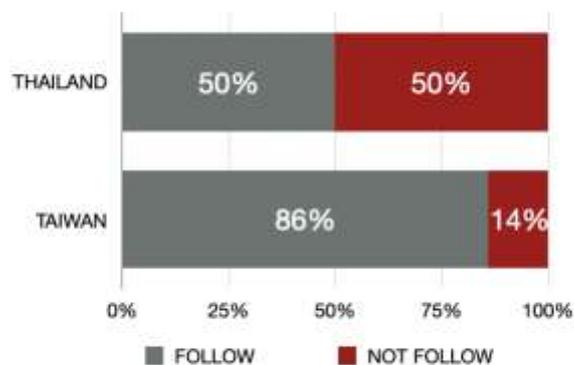


Figure 5: Public Trust of Covid-19 pandemic technology survey

In addition, only 50% of Thai users follow official news or information from government agencies. On the contrary, Taiwan users have a higher official news consumption rate of 86% Bryer and Zavattaro (2011); Mergel (2013) research said social media was designed to bridge the gap between organizations or Government agencies and the general public. This gives the government the tools to make the intended goals more effective. See figure 5.

Apart from the result, both Thailand and Taiwan residents circulate rumors or fake news on the Internet about infectious diseases. Users of both countries have similar ways to counter fake news, which can be summarised in three ways, (1) search more information, (2) recheck with a variety of news sources for more consideration (3) ask close people. The difference between Thailand and Taiwan is that Thailand users have a way to deal with fake news by deciding to trust reputable news channels or agencies and use personal judgment. Contrary to this, Taiwan users decide to trust announcements from the CECC Organization - Taiwan Centers for Disease Control official. Consistent with research by (Qiuyan *et al.*, 2020), governments should closely monitor social media channels to provide communication during the epidemic to update the information of news or policies in order to keep up with the interests of the people. Also, government agencies should adopt easy-to-understand language to address

what people are concerned about. The results of Thailand and Taiwan also show the government's ability to communicate affects people's trust in information, which is compatible with (Hu *et al.*'s, 2008) research. Gaining public confidence and a trusted organization or institution is tendentious to achieve the goal of engagement, particularly in decision-making situations. The role of trust in a civic context seems to be most salient in which the individual is assessing the fairness of a decision outcome or decision-making process. (Gordon *et al.*, 2013; Terwel *et al.*, 2010) In the research of Hu *et al.* (2008) According to Bengio *et al.* (2020) mentioned encouraging control the spread of infection effectively, as people's trust in technology is a key to diffuse adoption of technology.

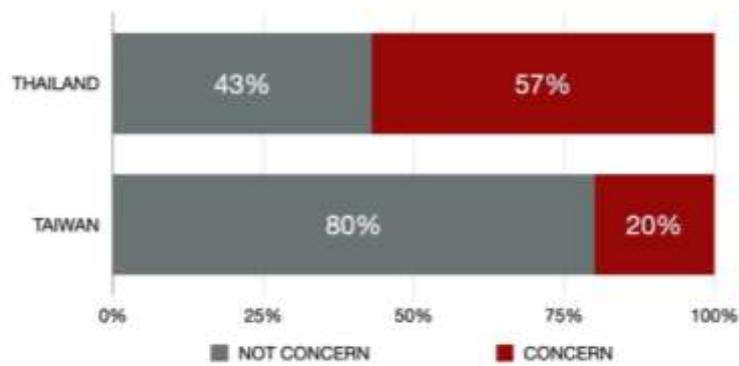


Figure 6: Digital Privacy of Covid-19 pandemic technology Survey

Penetrating the usage of technology, it was found that as many as 57% of Thai users were concerned about the safety and privacy of their personal data, while only 20% of Taiwan users were concerned. The result is consistent with the research by Bengio *et al.* (2020); Hung and Wong (2009), which mentioned that users need more concise information surrounding privacy protection, especially in a democratic society, and they tend to be more concerned about personal privacy and violation of personal privacy. If government continuously neglects the infringement of people's privacy rights or lacks an attitude on privacy concerns, people's trust in that technology will decrease. See figure 6.

Another reason why Thai volunteers continue to use technology is due to mandatory regulation of pandemic disease control policy, such as vaccine certificates for entering some the area, and vaccine registration and strictly check-in areas. On the other hand, even though concerned for personal safety but for the benefit of the public, Taiwan users argue about their continued use, in case of being infected or under surveillance. This is consistent with the research of Bimber (1994) that concluded technology-driven approaches might yield good results when enforced by laws, regulations, or objective proposals from governments and may result in reduced human freedom. From the results of collecting all the above-mentioned data, we can summarize the issues to answer research questions, as shown in Figure 7.

From the results of collecting all the above-mentioned data, we can summarize the issues to answer research questions, as shown in Figure 7.

The core technology to encourage the pandemic disease control situation in this study was divided into four stages. The study was limited in terms of duration, allowing only three stages to be studied. From a comparative study in Stage 1, Thailand and Taiwan had technologies in Screening for Information and Clinical Management before the occurrence of the Covid-19 epidemic. In Stage 2, technology in Quarantine & Self-isolation and medical supplies are technologies that Taiwan has developed and enhanced control of infectious disease, which is related to the number of infected people in the country. For Stage 3, Contact tracing technology is important as both Thailand and Taiwan successfully implemented this, with results showing that most volunteers use it. The factors affecting the usage of technology in a pandemic situation are regulations or policies announced by the authorities and the security of privacy protection. In addition, from in-depth interviews and questionnaires from 46 real users in both countries, it was found that factors in the diffusion of innovation and factors of communication technology contributed to enabling the technology released along with the situation control policy to be effective. Furthermore, the difference in users of Thailand and Taiwan is the factor of trust in information towards the center of government affect to public engagement lead to makes the policy effective in controlling the epidemic situation. In addition, users in Thailand also have privacy concerns, but the reason for the adoption of the technology comes from policy regulations or digital governance.

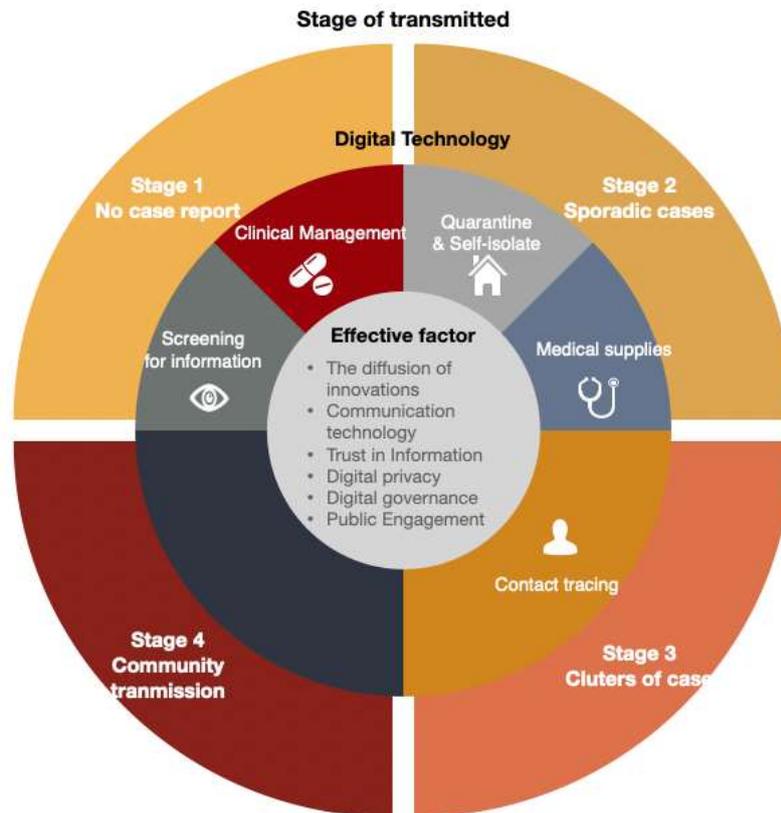


Figure 7: Technology-enabled innovations to combat Covid-19 pandemic

## CONCLUSIONS

Table 7 summarizes the technology and Effective factor to focus under this research. During the first stage, or before the outbreak in the country, screening for Information and Clinical Management technologies are the main part of a support for the pandemic situation, although there were other types of technology developed during this period. However, the factor in the diffusion of innovation limited people to adopt the technology timely manner. For example, Taiwan focuses on an organization's technology using in-house development along with regulations that encourage better infection disease control. In addition, during the first stage, communication technology is an important part of making people aware of and understanding the nature of the epidemic as quickly as possible, such as using more variety of social media channels to communicate with other people. In order to access more information from all groups, governments or regulators should focus on building trust that concerned with information because it plays an important role in building public trust, leading to the adoption of technology in the long term, including the creation of public engagement that will have a positive effect of the policy to have better control over the epidemic.

In Stage 2, Quarantine & Self-Isolate and Medical Supplies technology have contributed to Taiwan's success in controlling the pandemic situation and kept the number of detected in Stage 2 for a long time or slowly disseminated to entering Stage 3. In this stage, the spread of information and regulations will encourage people to adopt the use of technology.

In Stage 3, Contact Tracing technology plays an important role in controlling the infectious disease situation in this period. From in-depth interviews, factors of public engagement and the enforcement of policies have contributed to the adoption of contact tracing technologies. However, although enforcement will enable the adoption of the technology, the privacy factor is still a major concern for users who refuse to use technology. Through non or weak regulations, factors in the public trust to regulators may have an effect on public privacy concerns, but not enough to convince the public to concede technology at first. Therefore, digital governance is a very significant factor in Stage 3. Governments or regulators should be closely monitored to ensure that the technology's privacy policy is beneficial and accessible to the people.

Additionally, the increasing number of technologies during this period did not contribute to controlling the pandemic situation. The governments or regulators should focus on developing practical technology and relay the benefits of technology to the people so they can understand how to use the technology at its full compacity and usability.

Table 7: Technology and Effective factor to focus under this research

	Stage 1	Stage 2	Stage 3
Technology to focus	<ul style="list-style-type: none"> <li>• Screening for Information</li> <li>• Clinical Management</li> </ul>	<ul style="list-style-type: none"> <li>• Quarantine &amp; Self-isolate</li> <li>• Medical supplies</li> </ul>	<ul style="list-style-type: none"> <li>• Contact tracing</li> </ul>

Effective factor to focus	<ul style="list-style-type: none"> <li>• Diffusion of innovation</li> <li>• Communication Technology</li> </ul>	<ul style="list-style-type: none"> <li>• Digital Privacy</li> </ul>
	<ul style="list-style-type: none"> <li>• Digital Governance</li> <li>• Trust in information</li> <li>• Public Engagement</li> </ul>	

### ACKNOWLEDGMENT

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## Text Mining-Based Patent Analysis of Blockchain Technology Applications

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### ABSTRACT

This study focuses on the emergence of blockchain-related technologies regarding patenting activity. Blockchain technology has gained the attention of the general public. It has intensified in recent years, making it a fascinating subject of study for a patent analysis to scrutinize the evolution of this technology. However, research using the patent landscape to study the evolution of blockchain technologies is scarce. This article follows a unique methodology and comprehensive search strategy based on patent mapping and text mining to identify and categorize Blockchain patent documents extracted from the United States Patent and Trademark Office and the World Intellectual Property Organization databases. This methodology and dataset can be used for patent landscaping exercises or bibliometric analysis.

*Keywords:* Blockchain technology, patent landscape, text mining, topic identification.

### INTRODUCTION

The idea of Bitcoin and Blockchain dates back to 2008 when a person (or group) with the pseudonym Satoshi Nakamoto proposed bitcoin as the first cryptocurrency to solve the double-spending problem without the need of a trusted authority or central server (Kakarlapudi & Mahmoud, 2021; Paulavičius, Grigaitis, Igumenov, & Filatovas, 2019). Today, hundreds of digital currencies have been created using a secure blockchain-based technique. These innovations make it possible to manage a distributed database and maintain records for digital transactions of all types, as blockchain-based transactions create quick and inexpensive public records. But, the innovative importance of blockchain and the fact that it is an open-source technology has strongly encouraged the development and use of this technology in many applications that go beyond cryptocurrencies (Abou Jaoude & Saade, 2019; Xu, Chen, & Kou, 2019). Given this enormous potential, many companies using Blockchain technologies have opted to protect their inventions by patenting their innovations. So, the last few years have seen a rush to patent Blockchain technology. This makes this hot topic a fascinating field of study for a patent analysis to know the trends and developments in a given technology (Clarke, Jürgens, & Herrero-Solana, 2020; Evangelista *et al.*, 2020).

Patents are formal agreements between all relevant parties involved in the technological innovation process. Those parties include the inventor, the government body, the assignee, and any entity designated by the government regarding information about technological innovations and their rights of use. Typically, organizations rely on intellectual property rights through patents to develop other advanced technologies (Chen, James Lin, Chang, & Liu, 2009; Kim & Bae, 2017) or to determine an efficient technology management strategy and identify technological trends in a specific field of technology (Choi & Song, 2018; Lee, Yoon, Lee, & Park, 2009; Li, Xie, Jiang, Zhou, & Huang, 2019). Hence, patent landscaping may be considered an ideal tool to identify the evolution of emerging technologies such as blockchain. This tool uses a detailed search strategy, including keywords and a patent filtering strategy. While noting the paucity of researches using patent landscaping in studying Blockchain technologies, Clarke *et al.* (2020) present a comprehensive search methodology and strategy for identifying Blockchain patent documents using a combination of keywords and specific patent classification. This query was built in cooperation with the European Patent Office (EPO). They showed that although in 2014, more than 70% of patents were related to cryptocurrencies, this percentage fell to 40% in 2017. It concludes that blockchain is slowly becoming a General-Purpose Technology. Unlike the previous work, which focuses on the EPO database, our study employs an automated patent landscape analysis coupled with text mining technology to scrutinize data coming from the United States Patent and Trademark Office (USPTO) and the World Intellectual Property Organization (WIPO) databases. In a case study, we applied the search strategy to analyze worldwide blockchain patenting from 2007 till 2020.

### MATERIALS AND METHODS

#### Patent Landscape

Patent landscape analysis is a methodology using multiple sets of indicators to identify the evolution of a specific technological field (Bubela *et al.*, 2013; Carbonell, Gök, Shapira, & Faulon, 2016; Dhankhar, Gulati, Kumar, & Kapoor, 2018; Stoffels, Klauck, Hamadi, Glorius, & Leker, 2020). Although the notion of "patent landscape" may vary in scope and scale, it is

increasingly used to map trends in science and technology. In addition, text mining modeling, an artificial intelligence technology using natural language processing, can be applied in researching and clustering important technology-related thematic (Hassani, Beneki, Unger, Mazinani, & Yeganegi, 2020; Kumar, Kar, & Ilavarasan, 2021). Therefore, automated patent landscaping analysis and text mining modeling appear to be the appropriate methodology to study the evolution of blockchain technology. We employ ClusterMap, a text mining technology provided by IPTech, to exhibit the layout of technical topics.

**Search Parameters**

The starting point of the analysis is the consideration of the query list proposed by Clarke et al. (2020). The search of patent documents was conducted in InnoVue platform (https://www.innovue.ltd/) via its comprehensive search tool, IPTech, that gives access to patent applications filed with national and regional patent offices around the world such as the United States Patent and Trademark Office (USPTO) and World Intellectual Property Organization (WIPO). All searches were done on September 22, 2021. The search strategy used in this work is presented in Table 1.

Table 1: Search query.

Candidate	Search string
Blockchain patents	all-US;WO-TA:(Blockchain* "Block-Chain" Bitcoin* "Bit-coin" Blocksign Codius "Colored-Coin" "Colored-Coin" Cryptocurrenc* "Crypto-Currenc" "Distributed Ledger" Dogecoin "Doge-Coin" Ethereum Factom Litecoin "Lite-Coin" "Pay-To-Script-Hash" P2SH "Proof-Of-Stake" Sidechain* "Smart-Contract" Smartcontract* Zerocash Zcash Chaincod* Counterparty XCP Digitalcurrenc* "Digital-Currenc" "Hash-Tree" Hashtree "Meta-Coin" Metacoin* "Name-Coin" Namecoin* "Proof-of-Work" "Hash-Cash" Hashcash Rootstock RSK Ripple Stellar Symbiont "Type-Coin" Typecoin* Zerocoin "Zero-Coin" Zeroknowledge "Zero-Knowledge")

US: United States Patent and Trademark Office; WO: World Intellectual Property Organization; TA: Title and abstracts

**Data Analysis**

From the search query, 12514 patent documents whose publication date starts from January 11, 2007, to December 31, 2020, were retrieved using manual screening and duplicate removal. Documents are then organized by type of ownership and content. Therefore, the analysis is limited to the document content and the period specified in the research. Fig 1 displays the accumulated number of patents applications published between 2007 and 2020.

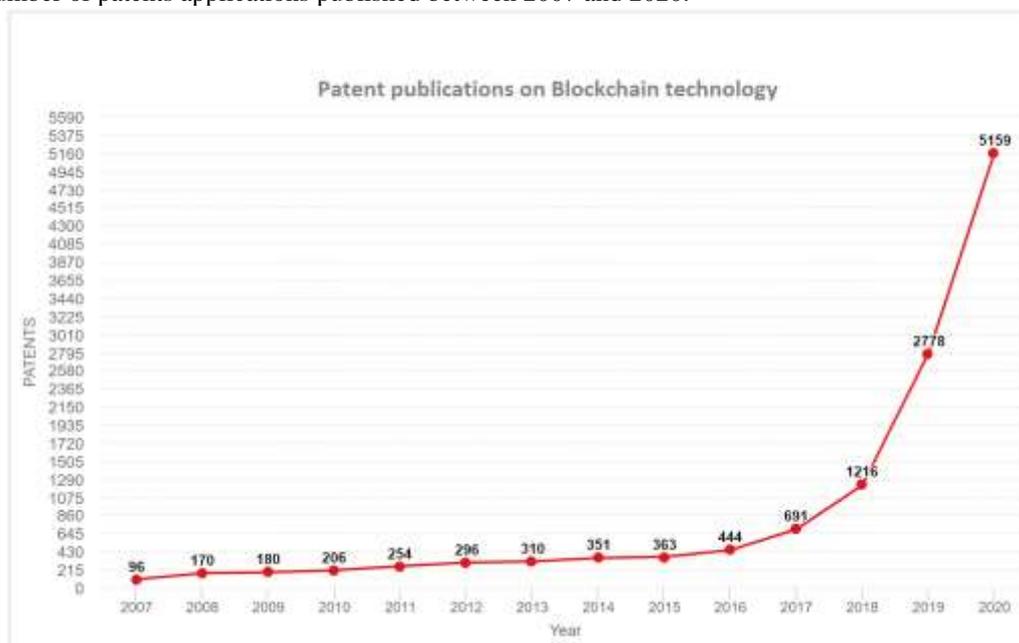


Figure 1: The trend in patent publications for blockchain technology applications.

**RESULTS**

**Topic Identification**

We extract potential topic identification from the title, abstract, claims, and descriptions of all the gathered patents (Fig 2). The top 10 possible English topics are Blockchain network (2283 patents), Smart Contract (1252 patents), Computing Device (919 patents), Storage medium (483 patents), Digital Asset (281 patents), Hash tree (170 patents), Financial transaction (157

patents), Electronic document (67 patents), Machine learning (65 patents) and Virtual currency (65 patents). Blockchain networks refer to patents describing a process related to different blockchain networks. For instance, the patent application WO2020020674 introduces a communication interface to a public network and a controller to manage a transaction, while US10764259 details transaction processing for a consortium blockchain network. Smart contracts are simply programs stored on a blockchain that execute when predetermined conditions are met. An electronic document is exchanged between business partners in an electronic format. For example, the patent with the public number WO2020001103 describes a blockchain-based electronic signature method and apparatus. An electronic device receives a target transaction initiated by a subscribed user. Machine learning refers to patent documents that describe intelligent provisioning systems of a distributed ledger technology network that can be configured to receive provisioning requests from authorized users on a plurality of predefined parameters. For instance, US20200174463 presents a predictive system that involves a facility for analyzing surveillance data via a collection network. The subsequent classification includes a public key and central counterparty, as shown in Figure 3. Overall, this topic identification could be a starting point for further interpretation and in-depth analysis.

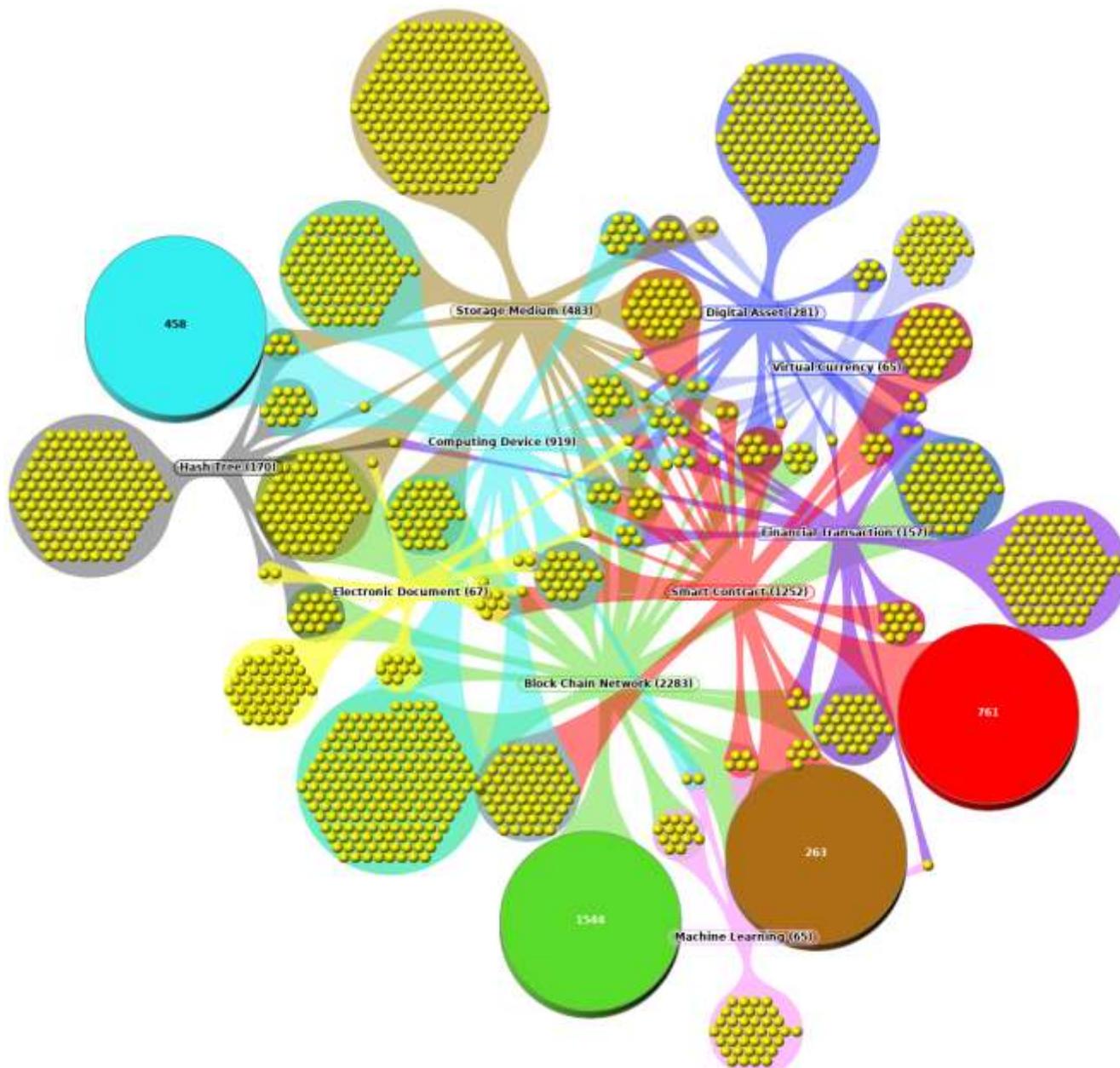


Figure 2: A network analysis of the top 10 English topics.

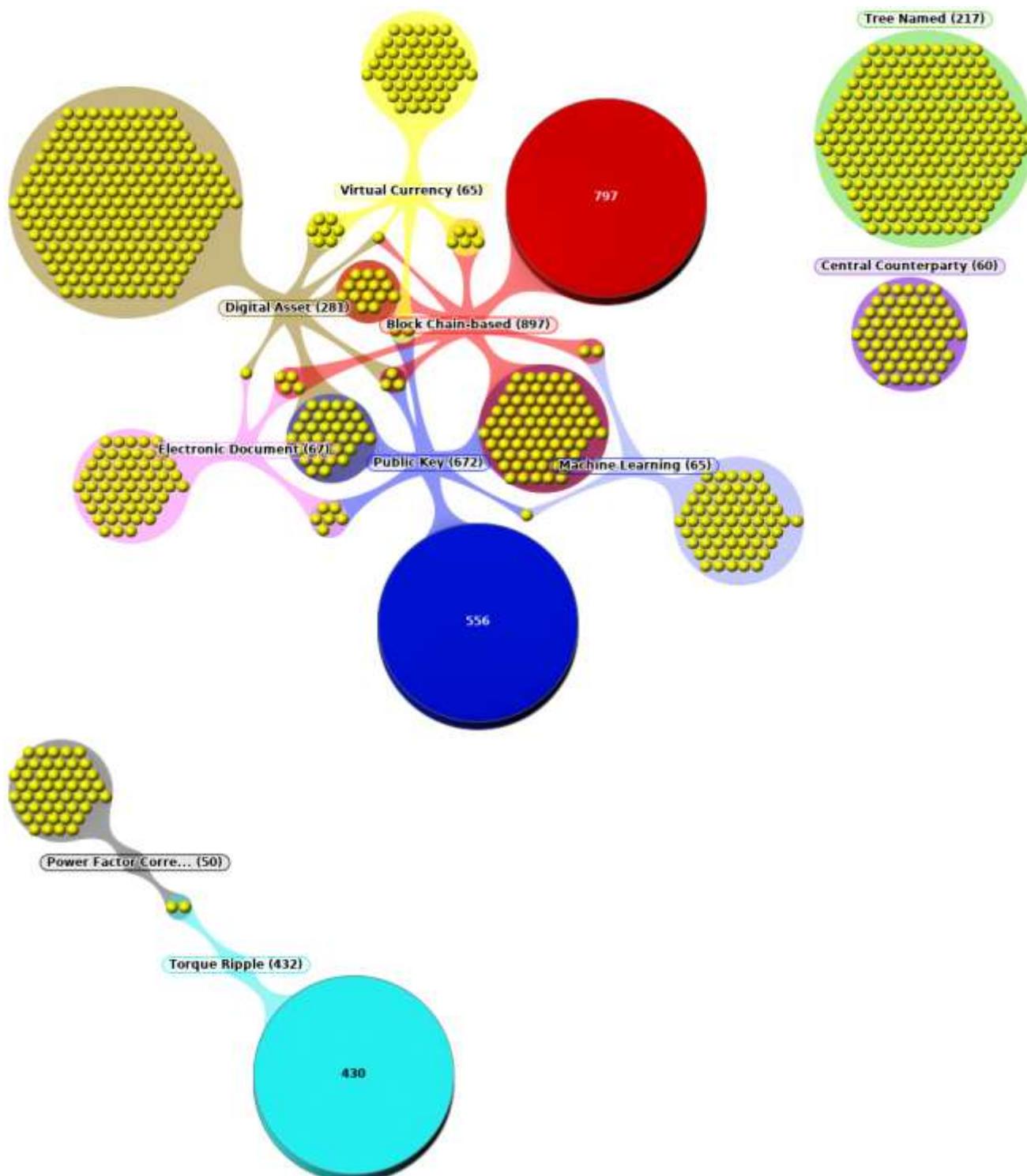


Figure 3: ClusterMap of subsequent topics.

**Classifications**

Based on data mining results and International Patent Classification (IPC) level 5 analysis, the patent documents could be organized into four groups: type of networks, IPC, crypto-assets, and industrial applications, as shown in Fig. 3. Blockchain networks involve public, private, permissioned, and consortium blockchains, while IPC includes computing devices and digital information. Crypto-assets refer to cryptocurrency and utility tokens, whereas industrial applications involve information technology (IT) services, banking, financial services, Healthcare, Media and entertainment, and Supply chain management.

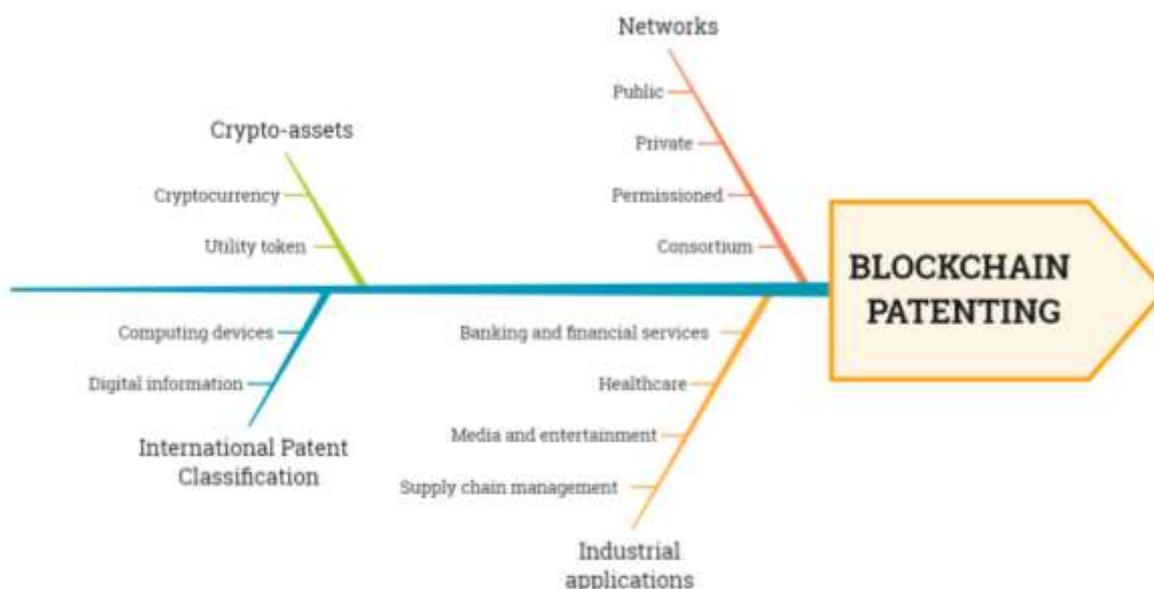


Figure 4: Blockchain patent classification.

**Blockchain networks**

Patents related to blockchain networks include public, private, permissioned, and consortium blockchains (Table 3). Public blockchain networks are blockchain networks where anyone can join as there are no real restrictions on participation. It was found that 158 patents are related to public blockchain networks. Those technologies are mostly related to systems and apparatus for blockchain-based consensus process to enhance security. For example, the invention with the publication number WO2020098837 discloses methods, systems, and apparatus for processing blockchain-based guarantee information.

In contrast, private blockchains are not open for the public people to join in. A single organization or institution controls them. Like public blockchain, patents related to private networks mostly cover security enhancement and encryption algorithms. For instance, WO2020098836 describes a method to verify whether one or more zero-knowledge proofs are correct after receiving a ciphertext.

Permissioned blockchains differ from public and private blockchains. They maintain a layer of access control to allow specific actions only by sure identifiable participants. Patents related to those technologies mostly describe techniques to record, manage, and transfer ownership rights. For instance, the patent identified as US20200074470 details a process to transfer an asset from an asset provider to an asset requester while determining whether the request is valid or not. A consortium blockchain is a platform where multiple organizations control and manage the network. Patents related to consortium blockchain consortium include methods and apparatus for controlling authorization to access user data. It should be noted that some patent documents such as US10880077, WO2020098840, and US10872170 belong to more than on blockchain networks.

Table 2: Distribution of patents based on the type of blockchain networks.

Network type	No. of patents	Publication No. <sup>a</sup>
Public blockchain networks	158	US10880077; WO2020098840; WO2020256831; US10872170; WO2020098837; US20200394085; WO2020098836; WO2020098838; WO2020098834; US10855449
Private blockchain networks	147	US10880077; WO2020098840; US10872170; WO2020098837; WO2020098836; WO2020098838; US20200382372; US20200382509; US10855447
Permissioned blockchain networks	105	US1087852; US20200389301; US20200380825; US20200380826; US10848622; US20200364735; US10833845; US10834095; US20200344073; WO2020216536
Consortium blockchains	272	US10880077; WO2020098839; WO2020098840; WO2020256831; US10872170; WO2020098837; US20200394085; US10867299; US10868673; WO2020098836

<sup>a</sup> Our table includes the ten more recent applications based on publication date.

### International Patent Classification (IPC)

IPC includes digital information and computing devices, as presented in Table 4. The digital information subgroup can be further divided into two components: arrangements for secret or secure communication (H04L 9/32) and arrangements for communication processing (H04L 29/06). Patents related to those technologies mostly describe systems and methods for cryptographic zero-knowledge proof and Merkle-tree-based Proof-of-Work aimed to enhance information security and accessibility. For instance, US10848312 describes systems and methods relating to a zero-knowledge architecture between multiple systems. At the same time, US10873461 discloses systems and methods for zero-knowledge multiparty secure sharing of voiceprints.

Computing devices include two components which are payment architectures and protocols (G06Q 20/38) and Finance and exchange category (G06Q 40/04). Patents related to payment architectures and protocols mostly detail methods and devices for publishing smart contracts and checking their accuracy. For instance, US20190318349 details a method for controlling a smart contract in a network. This method involves accepting the details of the smart contract and evaluating the fulfillment of the conditions. On the other hand, finance, insurance, and detailed exchange information about systems and methods for providing financial data to financial instruments in a distributed ledger technology. For example, US20190164223 provides a system for tracking information related to a financial asset via a distributed ledger.

Table 3: Analysis of blockchain patents using IPC level 5.

	Classification	IPC code	No. of patents
Digital information	Arrangements for secret or secure communication	H04L 9/32	797
	Arrangements for communication processing	H04L 29/06	783
Computing device	Payment architectures and protocols	G06Q 20/38	568
	Finance; insurance, and exchange	G06Q 40/04	297

### Crypto-assets

This category includes cryptocurrency and utility tokens, as presented in Table 4. It was found that 1711 patents with the term cryptocurrency are mentioned in their abstract, title, claim, or description. Those technologies are mostly related to systems and methods for using a shared platform to transmit cryptocurrency. For example, the invention with the publication number WO2020091103 relates to applying a blockchain-based cryptocurrency transaction rule and a terminal device for executing it. The method includes receiving a transmission request for a cryptocurrency transaction.

Results show that 460 patent documents are directly related to a utility token. This blockchain-based asset can help finance future projects. For instance, the patent identified as US20200328891 describes using intelligent, blockchain-compatible asset tokens for non-fungible assets. The intelligent asset tokens can be customized within a three-layer hierarchical identifier representing a hierarchy of asset data.

Table 4: Distribution of patents based on the type of crypto-asset categories.

Crypto-asset category	No. of patents	Publication No. <sup>a</sup>
Cryptocurrency	1711	US20200410480; WO2020258125; WO2020260864; WO2020258126; WO2020263212; US20200402061; US20200402091; US20200394619; US20200394620; US20200395761
Utility token	460	WO2020255372; WO2020252036; US10848449; WO2020212452; US20200328891; WO2020199135; US20200311698; US20200302429; WO2020176228; US10762506

<sup>a</sup> Our table includes the ten more recent applications based on publication date.

### Industrial applications

Applications include IT services, banking, financial services, healthcare, and supply chain management, as shown in Table 5. Our search strategy reports that IT companies are the leading patent holders of blockchain technology. For instance, the international business machines (IBM) corporation reportedly filled 504 patents during the period starting from July 2006 to April 2020. Those technologies are mostly related to smart contracts and methods for a model-driven extraction of event data that represents an event on a blockchain network. Another IBM invention refers to a blockchain Uniform Resource Indicator (URI) that has access to a blockchain distributed among a plurality of peer blockchain nodes. Moreover, Mitsubishi electric returns 96 blockchain-related innovations. For example, the patent with the application number JP2020016034 details an entry/exit management system that eliminates the possibility of unauthorized access. This invention enables the sharing of a plurality of nodes connected by a P2P network. The authentication conditions are recorded in a block of the blockchain by a management node supervising all the nodes.

Additional results point out that MasterCard, Bank of America, and Visa are among financial companies that massively invest in the field of blockchain technology. Those patents are mostly related to methods and systems for trustworthiness using digital certificates. For instance, the patent application identified as US16947545 provides a way to generate digital certificates for anonymous users in blockchain transactions. This technique involves storing blockchain and transaction values. The central node determines a confidence level based on the data included in each transaction value. Similarly, the application US2020033077 describes a method of transmitting verifiable information regarding the provenance of a cryptographically accurate product while maintaining complete product and participant anonymity on a blockchain. This method includes receiving a product identifier, then generating a digital token by applying a hash algorithm and a digital signature using a private key of a cryptographic key pair.

We also found that companies such as Alibaba Group and Walmart hold inventions related to blockchain technology. Those patents disclose methods, devices, and apparatuses for executing cross-chain anonymous contracts. For example, the invention (US16938650) relates to a method and apparatus for identifying the authenticity of evidence from two parties based on a blockchain ledger. For a specific case event that the accused claims to be accurate, the accused's indictment evidence supporting the case event is identified through the target procedure. In addition, evidence of the respondent's response to falsify the event of the case is identified through the target procedure. At the same time, the patent identified by the application number US2019045627 discloses the system and method for product recall using blockchain. The sales transaction is recorded in a blockchain ledger, and the sales transaction includes customer identification information. A recall report is received regarding the product. The blockchain ledger is accessible, and customers who purchased the recalled product are identified using customer credentials. An action to be taken is determined. The action uses the contact details of customers who purchased the recalled product.

Table 5: Distribution of patents based on the type of crypto-asset categories.

Industry/Sector	Assignee/Company	Patents retrieved
Electronics and IT services	IBM	504
	Mitsubishi Electric	96
	Microsoft	94
	Siemens AG	93
	Intel	70
Banking and financial services	MasterCard	133
	Bank of America	117
	Capital One Services	73
	Visa	63
Healthcare	Ping An Technology	72
Supply chain management	Alibaba Group	450
	Walmart	81

### DISCUSSIONS AND CONCLUSIONS

The technologies relating to the blockchain are in a dynamic of solid growth and innovation. Some authors nickname it "General Purpose Technology" (GPT), that is, a key technology for the evolution of humanity. Such an essential technological field has a significant impact on patent applications. The patent landscape is an ideal tool to identify the evolution of emerging technologies such as blockchain. It uses a detailed search strategy, including keywords and patent filtering. However, research using the patent landscape to study the evolution of blockchain technologies is scarce. This article proposes a methodology based on the patent landscape and text mining to identify blockchain-related patents.

Based on data mining and international patent classification, the patent documents have been organized into four groups: network types, IPC, crypto assets, and industrial applications. Blockchain networks involve public, private, permissioned, and consortium blockchains, while IPC includes computing devices and digital information. Crypto-assets refer to the cryptocurrency and utility token, while industrial applications involve banking and financial services, healthcare, media and entertainment, and supply chain management.

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## The Effect of Blockchain on Customer-To-Customer Electronic Commerce

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### ABSTRACT

The popularity of the Internet and e-business has led more people to online shopping, especially customer-to-customer (C2C) electronic commerce (e-commerce). However, C2C e-commerce faces challenges such as security, product and vendor trust, and more. One of the most important solutions to such problems is the use of decentralized and distributed technologies such as blockchain, which play an important role in identifying, verifying, and validating data, developing information security, and creating transparency and trust in a business. Therefore, this study uses a qualitative method to investigate the effect of blockchain on C2C e-commerce. After conducting the conceptual study, the experiences of experts in this field were used through semi-structured interviews. The data from the interviews were then coded and analyzed. Finally, 12 conceptual codes were extracted. Due to the high frequency of the transparency code, other concepts were studied around this axis and based on it. According to the results, strategies such as transparency, trust, and legal barriers were more important in using blockchain in C2C e-commerce, respectively.

*Keywords:* Customer-to-Customer Electronic Commerce; Blockchain; Transparency; Trust; Security.

### INTRODUCTION

Today, advances in information and communication technology have had a great impact on various aspects of people's lives in society and the way they do business. This evolution and change have led to the transition to innovative ways of doing transactions such as e-commerce (Choshin & Ghaffari, 2017; Deng et al., 2020; Shorman, Allaymounq & Hamid, 2019). E-commerce is currently the most widely used type of commerce, which processes more than one billion transactions per day (Dennis & Owenson, 2016; Ismanto et al., 2019). E-commerce is the conduct of all business activities using computer communication networks, especially the Internet. In other words, e-commerce is a generic name for a range of software and systems that provide services such as information retrieval, transaction management, credit check, online payment, reporting, and account management on the Internet. These systems provide the basic foundation of Internet-based activities (Jozdani & Mozaffari, 2019).

The most popular and growing type of e-commerce is customer-to-customer e-commerce, in which the parties are trading through a platform provided by a third party (Liang & Liang, 2014). Transactions of this e-commerce are not limited to place and time, so the probability of successful transactions increases (He, Lu, & Zhou, 2008). Although C2C e-commerce has great development potential, it faces many problems (Deng et al., 2020), including fraud, commission costs, limited contact between seller and customer, and misuse of personal data that affects buyers' trust, buying behavior, and their willingness to buy (Deng et al., 2020; Ismanto et al., 2019). Besides, intermediaries are not liable for substandard goods sold, and no refunds are accepted, which also exacerbates buyers' distrust (Ofori et al., 2017). Therefore, Trust is an integral part of consumer behavior in the adoption of new technologies, including the Web and e-commerce (Kumar, Anand & Mutha, 2016). It is the foundation of e-commerce and refers to the relationship between the parties (Smits & Hulstijn, 2020). Trust is important because it helps consumers to overcome perceptions of uncertainty and risk and to share their personal information or purchase their intended goods and services (McKnight, Choudhury & Kacmar, 2002).

The Internet has made it possible for transactions to take place regardless of geographical restrictions, yet cybercrime has made consumers worry about security issues when conducting Internet transactions. Lack of trust in the seller has been shown to be an important deterrent to online trading. Due to the lack of rules and regulations in e-commerce and because the purchase of goods and services on the Internet is usually not immediately provable, the issue of trust in e-commerce is one of the most important obstacles to success in online shopping (Akman & Mishra, 2010, Yoon & Occeña, 2015).

In addition to trust, transaction security, privacy, and electronic payment system and logistics problems are also important in its adoption (Chang & Chen, 2009; Deng et al., 2020; Tombe et al., 2017; Yoon & Occeña, 2015;). Given the issues and problems that exist in such infrastructures, blockchain technology can be considered as a solution in this field (Shorman et al., 2019; Xu, 2016). Blockchain has the potential to shake the foundations of e-commerce by activating barter relationships that are

untrustworthy and operate on dedicated intermediaries. In addition, the exchange of information and value between companies and consumers may change significantly by providing integrated access to unchanging data throughout the supply chain (Treiblmaier & Sillaber, 2021).

Blockchain implementation can improve e-commerce and solve its problems (Deng et al., 2020; Ismanto et al., 2019). It can transform all financial systems and activities of many industries, financial institutions, banks, and service companies around the world without compromising the privacy, security of digital assets and stakeholders. Blockchain encourages peer-to-peer payments through cryptocurrency and requires no fees. It also allows buyers and sellers (senders and recipients of virtual money) to communicate directly with each other (Ismanto et al., 2019). By adopting blockchain to the e-commerce environment, merchants can use smart contracts to work with logistics service providers (Deng et al., 2020). The smart contract has a precondition that guarantees justice and security, and the head office creates a transparent and decentralized environment (Ismanto et al., 2019). Under such circumstances, e-commerce users can gain a better logistics experience (Deng et al., 2020).

Recent research has studied the use of blockchain in e-commerce in general as well as various types of e-commerce, especially business-to-business (B2B) e-commerce and even supply chain, but despite the increasing use of C2C e-commerce, little attention has been paid to the use of blockchain, in this business. Given the dramatic development of the C2C e-commerce that has led to the popularity of this business in the short term, and considering the characteristics and risks of C2C e-commerce, this question arises: What changes can the use of blockchain make in C2C e-commerce? To answer this question, this study aims to investigate the effect of blockchain on C2C e-commerce.

The rest of the study is organized as follows: after reviewing the research literature, research methods and findings are described; finally, conclusions and recommendations for future research are presented.

## LITERATURE REVIEW

Electronic commerce (E-commerce) is buying and selling through the Internet (Treiblmaier & Sillaber, 2021; Wen et al., 2011). It refers to the application of electronic communications and information processing technologies in business transactions (Gupta, 2014; Shorman et al., 2019; Treiblmaier & Sillaber, 2021). E-commerce involves the use of the Internet, the World Wide Web, and mobile devices to conduct business transactions (Laudon & Traver, 2016; Shorman et al., 2019). E-commerce through web-based technologies facilitates transactions at any time and place. This feature gives unlimited opportunities to those who have access to the Internet to connect with others (Hosseinpour & Mokhtarrezaei, 2014). It also allows customers more choices and faster comparisons. In addition, it allows users to interact, exchange, and compare customer experiences with other customers on the Web (Yoon & Oceaña, 2015).

There are different types of e-commerce include business to business (B2B), business to customer (B2C), customer to customer (C2C), business to government (B2G), and mobile commerce (m-commerce) (Nemat, 2011). Among them, C2C e-commerce has become widespread and is growing rapidly (Liang & Liang, 2014). The C2C e-commerce can take place in e-auctions, chat rooms, email groups and social networks, advertising websites, and more (Ofori et al., 2017; Turban et al., 2015). It involves transactions between customers through online platforms. In this type of e-commerce, customers place their ready-to-sell products on the auction sites, and platform suppliers provide search engine and trading capabilities to facilitate product sales (Laudon & Traver, 2016). One of the benefits of C2C e-commerce is the reduction of administrative and commission costs for both buyer and seller (Ofori et al., 2017; Turban et al., 2015).

In this type of e-commerce, transactions are not done in person, and the parties to the transaction are in virtual contact with each other so, it is necessary to provide a trust for both parties, especially the buyer (Tombe et al., 2017; Yoon & Oceaña, 2015). Trust is defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer & Davis, 1999, p. 712). However, there is a risk that the product will not be shipped or the quality of the product will not meet the buyer's expectations (Weltevreden & Rotem-Mindali, 2009). Besides, due to risks such as insecurity and disclosure of personal information, denial of transactions, unauthorized access, and alteration of information, trust plays an important role in terms of positive or negative effects on customer satisfaction and loyalty. (Lu, Wang & Hayes, 2012). Therefore, this type of e-commerce needs a reliable platform to attract more people and increase the ease of transactions (He et al., 2008; Ofori et al., 2017; Shorman et al., 2019; You, Li & Cao, 2010). One of the most important solutions to such problems is the use of decentralized and distributed technologies such as blockchain. It is a combination of several technologies that create a decentralized and reliable structure for recording, sending, storing, and displaying data (Harish et al., 2021; Hawlitschek, Notheisen & Teubner, 2018; Kshetri, 2017).

Blockchain provides high-security functions without the intervention of intermediaries and the provision of banking information by the buyer because all processes are encrypted, and all transactions of tracked individuals are recorded. It has a lot of reliability (Sheikh, Azmathullah & Rizwan, 2019). It allows users to maintain a shared database without the need for a trusted central controller so that any participant can log in or log out at any time. Algorithms determine the chronology of time-stamped inputs by encrypting individual transaction sets ("blocks") into each other via cryptographic hashes. Each block is connected to its predecessor through a hash reference, thus establishing order and integrity in the blockchain (Treiblmaier & Sillaber, 2021). Blockchain is a stack of technology that affects e-commerce through technical, legal, organizational, and quality issues as well

as consumer issues. It can use different consensus protocols to validate (Smits & Hulstijn, 2020) and opens up new opportunities with unprecedented technological possibilities, but at the same time, it requires critical evaluation of current business processes, such as practices involving sensitive customer data or the design of communication channels throughout the supply chain (Treiblmaier & Sillaber, 2021; Zetzsche et al., 2017). Blockchains can be classified into public and private chains as well as authorized versus unlicensed chains. A combination of these features leads to three different types of Blockchain technology: (1) in publicly licensed chains, all nodes can read transactions, but only authorized nodes can read write them; (2) in unlicensed chains, all nodes are able to read, send, and write transactions. And (3) in privately licensed chains, only authorized nodes can read, send, and write transactions (Treiblmaier & Sillaber, 2021; Tsai et al., 2017).

Blockchain has many applications in e-commerce and helps companies to overcome their challenges (Bulsara & Vaghela, 2020). It supports e-commerce, as it is very secure for data storage (Sheikh et al., 2019). A comparison between two systems in terms of payment, with and without the use of blockchain, showed that in a system without blockchain, the payment process is slower, processes are more costly, and the negative effects of the dispute resolution system are greater (Sheikh et al., 2019). One example of blockchain usage in e-commerce is the OmniBazaar, which is a place to buy and sell without the need for credit cards and bank accounts. The advantages of using this platform include eliminating intermediaries, no bank charges, using cryptocurrencies, and speeding up transactions. In this context, people can exchange through bitcoins and other digital currencies without the need for intermediaries. In this software, sellers can offer their products without having to pay, and buyers can search for the product and do not pay for the use of this platform. (E-commerce Platform OmniBazaar, 2018).

Considering the advantages of blockchain, researchers are looking to study the impact of this technology on electronic businesses to reap its benefits. For example, Arora, Sharma & Bhaskaran (2020) have studied the impact of blockchain on various aspects of trust, including security, privacy, brand, usability, reliability, availability, reputation, third party, risk, quality, appearance, and feel in E-commerce. They indicated that using blockchain can revolutionize e-commerce, as there are many processes that can be automated, and implementing Blockchain can help better the application of e-commerce.

Jiang et al. (2019) designed a blockchain-based model to protect the privacy of individuals while conducting electronic transactions. In this model, smart private contracts were used to keep the information of the parties involved in the transaction confidential and then increase trust in this plan. This model consists of three separate chains that will eventually be interconnected. These chains include the payment chain for financial transactions, the trade chain for commodity contracts, and the logistics chain for storing delivery information. Each chain operates in conjunction with the other chains. According to the results, using this blockchain-based platform will gain more trust due to the lack of third-party access to other people's transaction information.

Liu and Li (2020) study focused on cross-border e-commerce to propose a blockchain-based framework. They developed a set of related techniques and methods for achieving traceable products and transactions in supply chain management.

In another study, Ismanto et al. (2019) studied the use of blockchain, cryptocurrencies, and smart contracts for a secure and efficient transaction in Indonesia. They showed that implementing blockchain has the potential to improve e-commerce and solve its problems. They also indicated that smart contracts are a prerequisite for ensuring fairness and security. Besides, distributed ledgers create a transparent and decentralized environment.

Treiblmaier and Sillaber (2021), by proposing 19 research questions, indicated that how blockchain can be investigated as a future technology that has the potential to have a major impact on e-commerce. The study by Grover, Kar & Ilavarasan (2018) examined the impact of blockchain on B2B, B2C, and C2C e-commerce. Their results indicated that blockchain would increase efficiency, transparency, speed of operation, and trust in the fields of accounting, market analysis, process management, supply chain tracking, and many other areas.

Lahkani et al. (2020) also examined the impact of blockchain on B2B e-commerce and indicated that the use of blockchain would improve the efficiency of logistics and digital documents by 74% and 75%, respectively. Their results also indicated that the main advantage of using blockchain is creating a decentralized and secure database. In addition, it increases payment speed, reliability, and transparency of data transfer.

Another study by Joshi and Kumar (2020) on various issues related to existing C2C e-commerce and overcoming them using blockchain technology and cost estimation model indicated that the use of different aspects of blockchain technology leads to better evaluation of cost, provides data privacy, and creates a sense of trust in customers.

In a similar study, Shorman et al. (2019) presented a model for C2C e-commerce based on blockchain. This model facilitates the business processes between the customers and eliminates the main role of large commercial companies in controlling and regulating.

According to previous studies, the impact of blockchain on various dimensions of e-commerce, especially B2B, B2C, and B2G businesses and the supply chain, has been studied. However, few studies have examined the impact of this technology on the C2C business. In addition, no research in this field has been conducted in Iran. Considering opportunities that blockchain

technology can provide for C2C business development and its ability to create security and trust in transactions in this area, and given that the C2C business has received a great deal of attention and acceptance today and is constantly growing and evolving, the lack of research in this area creates a significant gap in research. Therefore, the need to fill this gap and take advantage of its future results is undeniable, which is the purpose of this study.

### METHODOLOGY

This study aims to investigate the effect of blockchain on C2C e-commerce. To this end, a qualitative method was used, and after conducting the conceptual study, to better understand and interpret the subject, the required data were collected through semi-structured interviews with experts in the field of blockchain and e-commerce. The questions were first stated in general terms, and then, to discover the hidden parts of the theories, possible questions were extracted and discussed from the answers of the interviewees, and finally, the interviews were coded.

The statistical population of this study includes experts who have sufficient information and experience in the fields of C2C e-commerce and blockchain. The statistical sample includes 10 academic experts and experts active in this field, whose opinions were examined to identify the characteristics and challenges of each field through interviews. Given the lack of experts in this field, experts were selected by using a snowball approach in which each expert introduces other experts in this field.

Then the data were coded to analyze the data from the interviews. Coding was done in three stages of open coding, axial coding, and selective coding (Liamputtong, 2009; Smith & Firth, 2011). To encode the data, MAXQDA software was used. To evaluate qualitative research, terms such as acceptability, transferability, and verification are used instead of the word validity and reliability. Acceptability refers to being real. Pitney and Parker (2009) proposed methods to increase research acceptance that include multiple sources, multiple analysts, and multiple methods. In this regard, the research data was collected from various sources such as knowledgeable people and various written sources. The transferability of the research results indicates the generalizability of the results to other similar groups and environments. Although this is beyond the ability of a qualitative researcher, by extracting and presenting maximum data, this part of the validity of the research can be provided to some extent. Validation of qualitative research results is achieved when other researchers can follow the research path and actions taken by the researcher. In this research, an attempt was made to do this ethically.

### FINDINGS

Coding was used to analyze the data, and the data were encoded in three stages of open, axial, and selective coding. In the open coding stage, the concepts in the text of the interviews were extracted, and specific categories were identified for these concepts. For this purpose, according to the literature review and based on the purpose of the study, 12 conceptual codes including privacy, the challenge of specialists to develop blockchain, lower cost of transactions, reducing fraud and fraud, user experience, technological barriers, public blockchain, the immutability of information, security, legal barriers, transparency, and trust were identified, and their characteristics and dimensions in the data were discovered and extracted from the interviews. These categories were selected based on prominent and influential factors in C2C e-commerce as well as the features of blockchain technology. After identifying the codes, the concepts in the interview texts were categorized based on these codes. In some cases, a combination of several concepts was observed, and duplicate concepts were eliminated (Table 1).

In the axial coding stage, one component was considered for each category of conceptual codes. The results are presented in Table 2. As the table demonstrates, the highest frequency belongs to transparency, which indicates the great importance of this component and the need to pay attention to it.

In the selective coding stage, an analysis was performed to understand the relationships between the different codes. Due to the high frequency of the transparency code, the concepts were studied around this axis and based on it. According to the results, the close relationship between the transparency code and the category of "trust" is significant. In fact, despite the transparency that blockchain technology creates through its distributed and decentralized capabilities, it builds trust in the network, followed by trust in transactions and nodes. Such transparency in the presentation of information and its immutability also reduces fraud in transactions. The immutability of information makes the transaction records available to everyone. This feature is very important for proving the transactions in C2C e-commerce. This feature and the transparency of records at all nodes minimize the possibility of fraud. However, there will be more legal barriers to the transparency of information as a result of the use of blockchain, as public opinion has not yet changed to accept this level of transparency in transactions and the transfer of information. Therefore, legal barriers are chosen as the intervening factor. To develop this blockchain-based system, the presence of specialists and facilities is required. The consequences that will emerge in this system are related to the categories of "trust" and "reduction of fraud." The results are shown in Table 3

### DISCUSSION AND CONCLUSION

Online retailers have grown exponentially in recent years. However, they have faced challenges in how to communicate with customers and create security, reduce costs, provide high-quality services, and gain the trust and satisfaction of their customers. One of the most important solutions to such problems is the use of decentralized and distributed technologies such as blockchain. Using blockchain, businesses can turn payment, delivery, and transportation of goods into smart contracts. Therefore, in this study, the effect of blockchain on C2C e-commerce was investigated, which is the innovation of this research. This research can help the C2C high-tech and e-commerce literature, which requires applied research to cover various areas of e-commerce

operations that support the conversion of traditional operations to digital operations.

Table 1: Sample of Extracted Concepts and Concept Codes in Open Coding

Conceptual Codes	Extracted concepts
Privacy	Blockchain is secure in design and is considered a solution for cyber security and privacy protection.
User experience	The value of a blockchain network, like other networks, is the number of users. Accepting a network can increase the number of users. In the blockchain, despite the transparency of transaction details and users' trust in such a network, users will have a better and more satisfying experience, which in turn will increase the number of users.
The challenge of specialists	Developing an efficient and effective system requires the necessary specialists and facilities. Therefore, training in this field can be helpful in the adoption of this new technology.
Lower Cost	Blockchain is a technology that allows direct transactions between two users. Therefore, in blockchain, there are no intermediary costs per transaction. The volume of transactions in C2C e-commerce is low. So the transfer fee is low. In these small transactions, the transaction cost would not be higher than the transaction amount. So blockchain can cover this issue because transactions are done for free.
Public Blockchain	The development of public blockchain is significant for the implementation of this C2C platform. Private blockchain has limited use and is mostly used for a small segment or a specific entity.
Immutability of Information	The information recorded in the blockchain ledgers is not subject to change or manipulation. This makes the transactions between buyers and sellers, after registration, undeniable, and there is no possibility of violations in transactions. Unchangeable information.
Security	From a technical point of view, there are challenges related to security and blockchain acceptance within the network. Blockchain technology provides network security by assigning public and private passwords and digital signatures. Therefore, by using blockchain in the C2C business structure, more security will be provided for transactions.
Technological Barriers	In Iran, one of the problems is that blockchain is often known as money and bitcoin, not as a technology. This leads to the use of blockchain by monetary institutions that have problems with blockchain and bitcoin. Technological barriers
Fraud Reduction	Following the development of blockchain-based business, this system will allow users to track unchangeable transaction information. Therefore, there is no possibility of infringement in transactions.
Transparency	Blockchain, as a general distributed ledger technology, provides high-security information sharing and authentication of transactions by creating transparency in immutable information.
Legal Barriers	Following the transparency of information as a result of the use of blockchain, more legal barriers will be imposed because public opinion has not yet changed to accept this level of transparency in transactions and the transfer of information.
Trust	The development of blockchain-based trading will allow users to track unchanging transaction information, which in turn will increase trust in transactions in this area.

Source: This study

Table 2 : Frequency of Open Codes in Categories

Conceptual Codes	Coded Segments (All)	Coded Segments (Active)	% Coded Segments (All)	% Coded Segments (Active)
Privacy	2	2	2.06	2.06
User experience	4	4	4.12	4.12
The challenge of specialists	4	4	4.12	4.12
Lower Cost	4	4	4.12	4.12
Public Blockchain	5	5	5.15	5.15
Immutability of Information	6	6	6.19	6.19
Security	7	7	7.22	7.22
Technological Barriers	7	7	7.22	7.22
Fraud Reduction	8	8	8.25	8.25
Transparency	21	21	21.65	21.65
Legal Barriers	11	11	11.34	11.34
Trust	18	18	18.56	18.56

Source: This study

Table 3. Content of the Model Obtained From the Selective Coding

Causal Conditions	Main Category	Underlying Conditions	Interventional Conditions	Strategies	Implications
Fraud Incorrect information	Transparency	Technological issues The challenge of specialists	legal barriers	immutability of information Tracking transactions with blockchain	Increased security Increased trust Reduced fraud

Source: This study

The results indicated that transparency, trust, and legal barriers are the most important factors in the use of blockchain in e-commerce, respectively. Blockchain promises a set of new possibilities that regulators must fully understand before changing rules. Since in C2C e-commerce, people interact with each other on a peer-to-peer basis, and there is no guarantee that any kind of abuse will not occur, the issue of transparency and trust will be very important. Thus, the use of blockchain in C2C e-commerce provides an opportunity to optimize many processes, and with the help of this technology, many existing problems and difficulties can be managed with less cost and more transparency. Following such transparency, users' trust in this platform and consequently other users will increase, and this in itself will attract more users. With the increase in the number of users and the acceptance of this type of network, the necessary infrastructure must be provided to make the most of use of this technology. The important issues in this regard will be education and culture for the use of blockchain technology in various fields, including C2C e-commerce.

In addition, transparency should be considered in situations where there is a lot of fraud and abuse in online commerce, and it is not possible to track the accuracy of information. Optimizing security measures and strengthening various security channels in e-commerce programs to prevent identity theft, access to private data, etc., is essential. Besides, the security practices used in e-commerce must be developed; because different types of attacks and threats are still evolving. However, the development of an efficient and effective system often faces legal and technical barriers and a lack of specialized personnel. Many people oppose this technology because of the transparency of all transaction steps, the specificity of records, and the impossibility of misuse. The central bank's dominance over transactions has also diminished following the use of cryptocurrencies in transactions; therefore, it opposes its implementation. Lack of support to provide the necessary infrastructure and facilities will lead to a shortage of expert and developer staff. These factors will slow down the development and use of this technology. While having more technical facilities and expertise, better progress will be made in this area and will have a great impact on the user experience in using blockchain-based platforms. If the government does not try to use blockchain today, the same technology will become a threat later and shortly as it is today in the foreign exchange market.

An important feature of blockchain is its vastness so that it can summarize all the events around the product, which can be a commodity such as money, in a hierarchy and determine if someone wants to manipulate this chain. As a result, by facilitating key market functions, blockchain, if successfully adopted, could complement and compete with traditional electronic markets. Inclusive programs, on the other hand, can improve the customer experience through efficient content delivery and quick responses to customer requests. Therefore, to make a better experience with e-commerce for users, it is very important to use blockchain to ensure the normal implementation of all aspects to complete the purchase.

Furthermore, the development of blockchain-based business will allow users to track unchangeable transaction information, which will further increase trust in transactions and reduce violations in this area. Therefore, to implement this system in e-commerce, whenever the purchase cycle is completed, credit must be given to the manufacturer immediately; intermediaries must be eliminated; profits from factories and stores must be reasonable and controllable; hoarding of goods must be prevented; the production process must be distributed until it reaches the customer and the accuracy of transactions within this ecosystem must be confirmed.

Another issue that depends on trust is network security. There are many security concerns in the C2C business environment, including the security of confidential information and bank account information. Applying blockchain to the C2C business structure will create more security for transactions. In addition, in current C2C models, transactions are done with intermediaries. Intermediaries include both suppliers and the banks through which payments are made. These intermediaries charge a fee to carry out the transactions. The use of blockchain in these transactions, as shown in the analysis results, eliminates these costs. Therefore, transactions will be done free of charge.

According to the analysis of expert opinions, the public blockchain was more accepted. In this case, there will be no intermediary for centralized control, and all controls will be performed by the node consensus mechanism. Therefore, completely private contracts cannot be used due to the need for transparency in the content of transactions and the approval of other nodes. If the platform is based on transparency and trust, the information about the part of the transaction that relates to the type and number of goods, the delivery information, and the like should be clear.

A technical study of how blockchain and cryptocurrencies work can lead to research design in this dimension and provide a more detailed and technical model, which is a recommendation for future research.

Another issue that can be considered in a similar study is the potential of blockchain to adopt technologies such as the Internet

of Things. Research can be done by combining these two technologies for the C2C business. In addition, it is suggested that future research examine the impact of blockchain on a combination of B2B, B2C, and C2C businesses.

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## The Effect of Digital Literacy and External Information on Market Competition Fear: An Empirical Study on Fresh Food Consumption in China

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### ABSTRACT

The emergence of market competition fear is a new social phenomenon due to technological innovations and is worth studying. This paper explored the causes of market competition fear as well as the effect of digital literacy and external information channels on it. Data was collected from China by offline survey, and empirical analysis was used for hypotheses testing. The result shows that some specific competences of digital literacy have a negative impact on market competition fear. On the other hand, diverse external information channels have a positive impact on market competition fear, while the information from official news media can weaken fear. These findings confirmed that market competition fear exists in digital transformation. This paper can help to understand market competition fear and have positive practical significance for the government.

*Keywords:* Market competition fear, digital literacy, external information channels.

### INTRODUCTION

The outbreak of COVID-19 created an unpredictable external environment and led to the need to accelerate digital transformation. During the pandemic, digital technology has been widely applied to schools and companies. Organizations with higher levels of digital maturity are generally more flexible (Fletcher & Griffiths, 2020). Furthermore, digital technology has played a key role in the prevention and control of the epidemic. However, everything has two sides. People differ in their attitude toward digital transformation (Kharlamov *et al.*, 2021), and the application of digital technology has also caused a series of social problems. At the beginning of 2021, some Internet giants with enormous assets and advanced technology entered the community group buying market of fresh agricultural products. This affair attracted social buzz, and the hot discussion reflected the market participants' rejection and fear of these Internet companies entering the fresh food industry.

In fact, although the Internet giants have already entered several industries during the past few years, it was the first time that people expressed their fear before the emergence of a disorderly market. Up to now, the fear of society still exists, though the Internet giants do not corner the market, and offline food markets are operating orderly. The reasons are as follows. First, the digital economy has potential technical monopoly risk. Food demand is a rigid problem, which is closely related to people's life. Once the fresh market is monopolized by some companies, it will cause well-being problems. Second, there are many serious social problems that remained unsolved after the price war among the Internet giants, such as shared-bike cemetery, 996 schedules (work from 9 am to 9 pm, six days a week), and much unfair competition acts. Third, the participants in the traditional fresh market are more likely to believe that they may lose their jobs due to digital technology (Kharlamov *et al.*, 2021), especially when the employment environment is unstable during the pandemic. The reasons listed above help people to anticipate the detriments of competition in advance and make them have a sense of fear. It is a new social phenomenon and needs to be studied urgently.

Nowadays, building a digital society has become an irreversible trend. However, the appearance of fear will hinder the healthy development of the industry. In the future, digital technology will continue to apply to different life scenes. How to prevent market fear from appearing again? How to guide digital technology to effectively support the economy and society? These are important issues in the context of innovation-driven strategy. The attempt of this study can not only find out the causes of the market competition fear but can also provide the solutions to it.

Present studies on group fear at home and abroad are mainly based on public health emergencies. Public health emergency has the characteristics of unpredictability, destructiveness, and uncertainty of evolution. Therefore, people do not have plenty of time to make a reasonable decision but can only act on their emotions (Ni *et al.*, 2020). Sometimes, group fear is accompanied by a series of irrational behaviors such as scrambling for aid and panic buying (Fu *et al.*, 2021). Researches on group fear mainly began with the SARS incident in 2003. After a large-scale outbreak of COVID-19 in 2020, more scholars focused on the group's fear during the epidemic. As for technophobia, the fear caused by new technology, most studies focus on a specific technology and pay more attention to the resistance of fear to technological application. New technologies tend to break the people's original

technical environment and traditional habits, forming group fears, which have the strong interpersonal infection and social diffusion. In the 1990s, technophobia usually referred to serious anxiety caused by computers and other technologies, which directly led to the serious consequences of avoiding and reducing the use of a computer (Brosnan, 1998). Nowadays, technophobia also refers to the fear caused by various new technology like AI and the worry about unemployment caused by high-intelligence technology (Liang & Lee, 2017). Nevertheless, they fail to discuss the impact of technophobia on the market and rarely pay attention to the negative socio-emotion brought by the integration of new technology.

The Internet giants' entry into the community group buying market has triggered market competition fear, which provides an opportunity for this study to explore the market fear phenomenon. Thus, this paper carries out empirical research to expand the theories related to digital literacy and fear. In addition, the conclusions of this paper can contribute to the upgrading and optimization of the Chinese digital economy and better help society integrate with new technology.

## LITERATURE AND HYPOTHESES

### Market Competition Fear

As a kind of emotion, the research on fear is mostly concentrated in the field of psychology and medicine. In psychology, fear is a state of biological, mental activity, which refers to a strong depressive emotion produced by an individual when facing a dangerous situation. In medicine, fear is a self-defense response to a current, identifiable threat and is typically accompanied by a fight or flight response (Barlow, 2000). In terms of the effect on behaviors, fear often reminds people of the perception of risk or negative information and makes negative behaviors (Watson & Tellegen, 1985). From the perspective of emotional motivation, fear is a defensive emotion that prompts individuals to avoid risk (Ark & S., 2006). Nevertheless, individual panic behavior during an emergency is contagious, leading to collective panic behavior (Chen *et al.*, 2015), which is group fear.

In economics, the market is not only a physical place where goods are exchanged but also the sum of supply and demand between buyers and sellers. Participants in the market transaction include producers, consumers, resellers, and so on. The cause of the market competition fears this time was the emergence of new technology, which aroused the fear of job losses (Kharlamov *et al.*, 2021). Therefore, the market competition fears discussed in this paper refer to a strong negative group emotion that generates when the original market participants are unable to control the competitive threat caused by new technology. Besides, according to the group fear we discussed above, market competition fears also include the fear of unemployment, which consists of job insecurity and risk of job loss (Vuorikari *et al.*, 2016). From the perspective of the supply-side, if there is a monopoly in the market, it means market competition is disturbed. Competition failure leads to the continuous misallocation of resources to the monopoly enterprises. The existing competitors have no choice but to gradually withdraw from the market due to the lack of resources.

Existing competitors (greengrocers) in the fresh market are self-employed, mainly aged between 40 and 60. Most of them are undereducated with limited income. As far as they are concerned, the technological application breaks consumers' habit that they have to go to physical stores to buy fresh food. Besides, the involvement of the Internet giant breaks the competitive order. These two factors indirectly lead to fewer consumers and lower-income, which causes uncertainty about the future. While people who are intolerant of uncertainty are more likely to interpret all ambiguous information as threatening, leading to inaction and avoidance of ambiguous situations (Dugas *et al.*, 1997; Dugas *et al.*, 2001). Therefore, this paper argues that existing competitors in the market are fear of being squeezed out of the market, which includes uncertainty and unemployment fear. Thus, the following hypothesis is posited:

*H1: Internet giants entering the community group buying market has caused the market competition fear.*

### Digital Literacy

As the core of the fear that happened this time lies in technology, this paper believes that we should prevent and solve the fear from a perspective of technology, that is, to help in accepting new digital technology. And among all methods, the most critical way is to improve the digital literacy of existing competitors.

The concept of digital literacy was first formally defined in 1997, which is the ability to understand and use various digital resources and information displayed by a computer (Pool & Gilster, 1997). In the 21st century, the term digital literacy is used to describe the knowledge, skills, and dispositions necessary for successful participation (Greene *et al.*, 2014). After that, the DigEuLit (Digital European Literacy) project of the European Union defines digital literacy as awareness, attitude, and ability of individuals to properly identify, acquire, manage, integrate, evaluate, analyze and synthesize digital resources by using digital tools or digital facilities in specific life situations, so as to construct new knowledge, create media expression and communicate with others (Martin & Grudziecki, 2006). As digital technology has been integrated into all aspects of daily life, many basic necessities of life rely on digital devices. Digital literacy has become the core literacy of citizens in the digital society and is one of the necessary abilities for individuals to cope with life and work. It emphasizes more on critical thinking, which has an important impact on individuals' understanding, processing, and judgment of information (Pool & Gilster, 1997). There are a few kinds of research about the impact of digital literacy on behavior. Some studies suggest that individual digital literacy has a positive effect on users' performance and effort expectations which can facilitate the use of e-learning (Mohammadyari & Singh, 2015). In addition, the improvements in digital literacy can enable individuals to strengthen their control over personal information. Higher digital literacy is reflected in higher technical familiarity, higher awareness of institutional supervision, and

a greater understanding of privacy policies (Ball & Webster, 2020). Furthermore, the development of digital literacy can promote digital creativity (Chung *et al.*, 2015). Thus, we assumed that people with high digital literacy could dialectically and effectively use the acquired information and objectively understand digital technology.

Combined with the above considerations, we believe that improving the level of digital literacy can reduce the fear of external information on individual perception. In addition, it can make existing competitors more competitive, ensure job stability, and relieve their pressure of re-employment, so as to reduce the fear of unemployment. Therefore, whether digital literacy, as an individual characteristic factor, can alleviate the fear of market competition caused by technological progress? Thus, we suppose that:

*H2: Digital literacy has a significant impact on market competition fear.*

At present, there are many digital literacy frameworks that work to address the needs of different specific contexts. Most frameworks are used to measure the digital literacy of citizens (Neumann *et al.*, 2016; Vuorikari *et al.*, 2016). In DigComp2.1, digital literacy is divided into five competence areas: Information and data literacy; Communication and collaboration; Digital content creation; Security; Problem-solving (Carretero *et al.*, 2017). European Union also developed the framework for consumers (Brecko & Ferrari, 2016). Besides, some researches focused on measuring the digital literacy of educators and librarians in school (Guitert *et al.*, 2020; Hall *et al.*, 2014; Johnston, 2020). In digital transformation, digital technology is increasingly integrating into all walks of life, and more attention is paid to digital capabilities in various industries. At the same time, few papers have developed the framework to measure other occupations. This study will develop the digital literacy framework of operators based on prior researches.

The measurement dimensions of digital literacy used in this paper are based on DigComp2.1. Taking the features of the community group buying market into consideration, we selected four competence areas, which are information and data literacy, communication and collaboration, digital content creation, and problem-solving. These four dimensions are defined according to the characteristics of the trading scenario. That is fundamental to digital ability, digital social Ability, the ability to create digital content to acquire resources, and the ability to operate with digital technology. "Fundamental of digital ability" means the operator's knowledge and ability to use digital equipment and digital software; "Digital social ability" refers to an operator's ability and willingness to socialize with customers and suppliers through digital channels; "Ability to create digital content to acquire resources" refers to the ability that operators attract consumers and suppliers by creating business-related content on different social platforms; "Ability to operate with digital technology" refers to the operator's ability to manage transaction and operation by digital devices. Thus, on the basis of hypothesis 2, we propose the following hypothesis:

*H2a: Fundamental digital ability has a significant impact on market competition fear.*

*H2b: Digital social ability has a significant impact on market competition fear.*

*H2c: The ability to create digital content to acquire resources has a significant impact on market competition fear.*

*H2d: The ability to operate with digital technology has a significant impact on market competition fear.*

### **External information channel**

In the highly developed information age, the media and social networks played a significant role in informing civilians about various news. With a large number of users, it is easy to spread negative information among users and create a chain risk. Stimulated by such information, the feeling of fear forms among social networks and diffuses to other groups through media. Owing to the infectivity and transmissibility of fear, it not only affects the user group of digital technology but also affects the non-user group, forming a group effect. In the vast majority of cases, rumors and panic tend to go hand in hand (Ding *et al.*, 2021). Rampant information in various media channels is interspersed with a large number of rumors, promoting the breeding of negative emotions. Some studies have already explored the sources of fear-based on public emergencies such as COVID-19. In their research, internet information, fears and rumors from people around, and official news media (Hou *et al.*, 2020) are regarded as three of the sources of fear. When in the fresh market, greengrocers are close to each other and communicate frequently. This gives them more opportunities to contact people around them, so the information and rumors from people around them are more likely to affect them, which increases their job insecurity and exacerbates their fear. On the other hand, some studies found that official guidance instructions can effectively control the spread of panic if emergencies happen (Li *et al.*, 2019). Thus, the following hypotheses are posited:

*H3: External information has a significant impact on market competition fear.*

*H3a: Internet information has a significant impact on market competition fear.*

*H3b: Information and rumors from people around have a significant impact on market competition fear.*

*H3c: Information from official news media has a significant impact on market competition fear.*

Based on the above hypotheses, our research model is shown in Figure 1.

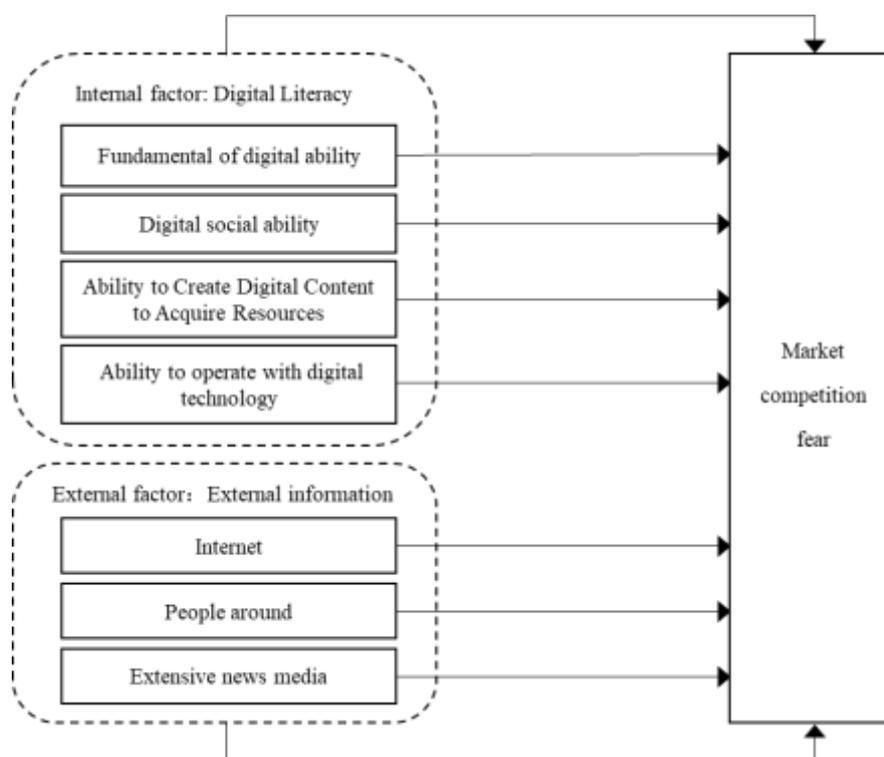


Figure 1: Theoretical model.

## MEASUREMENT

### Data collection

#### Participants.

Data were collected from 248 greengrocers from different fresh markets in China through a face-to-face survey. There are 239 participants who provided usable information, representing a response rate of 96.4%. Among these remaining 239 participants, 93 are males, and 146 are females. Only 7.1% are undergraduates, and the degree of the remaining people is lower than the bachelor's degree. In terms of city distribution, these participants come from different regions of China, including Shanghai, Jiangsu, Zhejiang, Sichuan, and other cities in China.

#### Procedure and materials.

Considering that greengrocers are busy greeting consumers during work time and most of them are undereducated, we conduct an interview to help them understand the questions. Before it, each participant was told the news about Internet giants entering the community group buying market. The formal survey was divided into two parts. The first part was about the demographic variables of greengrocers. The second part measured the digital literacy of participants, the degree of market competition, and the effect of separate media channels.

### Measures

#### Digital Literacy.

We considered the digital literacy of greengrocers was made up of 4 dimensions. That is fundamental to digital ability, digital social ability, the ability to create digital content to acquire resources, and the ability to operate with digital technology. The whole scale was designed on the basis of DigComp2.1 (Carretero *et al.*, 2017). The scale contains 15 items, and all the items were rated on a three-point Likert scale (1: strongly disagree, 3: strongly agree). A sample item from Digital Literacy was "I know the current popular social media platforms." The Cronbach's alpha was 0.899.

#### Market Competition Fear.

We used the uncertainty concern and fear of unemployment to measure the market competition fear of greengrocers. The scale contains 11 items. All measures were answered on a five-point Likert scale (1: Strongly disagree to 5: Strongly agree). The measurement of uncertainty concern refers to the uncertainty scale developed by Yao (Yao *et al.*, 2021). A sample item from Uncertainty Concern was "I am worried because I am not entirely sure what will happen in the future." The measurement of Fear of Unemployment refers to the Chinese General Social Survey (2015). A sample item from fear of unemployment was "I fear I may lose my main source of income." The Cronbach's alpha was 0.910.

#### External Information Channels.

We used the External Information Channels to measure the effect of different information channels on fear. The three-item scale was developed by Hou (Hou *et al.*, 2020), which was Internet information, people around, extensive news media. All the items were rated on a five-point Likert scale (1: Strongly disagree to 5: Strongly agree). The Cronbach's alpha was 0.875.

All the details of the scale can be checked in Table 1.

Table 1: Variables and their measures.

Variables		Measures
Digital literacy	Fundamental of digital ability	I know and use the instant messaging app.
		I know and use search engines.
		I know and use some popular social media platforms.
		I know and use the commonly used online shopping platforms.
		I know and use Alipay and WeChat Pay.
	Digital social ability	I use instant messenger to keep in contact with customers.
		I use instant messenger to keep in contact with my counterparts.
		I use instant messenger to keep in contact with suppliers.
	Ability to create digital content to acquire resources	I release copywriting and pictures on social media to promote products.
		I attract potential customers through short videos on social media.
		I attract potential customers through live streaming.
		I can get competitive suppliers through the Internet.
	Ability to operate with digital technology	I collect money from Alipay, WeChat Pay, or other third-party payment companies.
I use digital technology to manage the financial situation of the operation.		
I use digital technology to keep track of the stock.		
Market competition fear	Uncertainty concern	I feel uncomfortable if the changes in the industry are unpredictable.
		I felt nervous and anxious in the face of a steady diet of price-off promotions.
		I feel nervous about the Internet giants using price war to seize the market.
		I feel worried if I am not entirely sure what will happen in the future.
		I feel worried if the government does not have a clear regulatory policy.
		It is hard for me to adapt if the market mode is constantly adjusted due to changes.
	If possible, I would like to avoid being in such an uncertain situation.	
	Fear of unemployment	I'm worried about losing my job.
		I'm worried about losing my main source of income.
I think it will be difficult to find another job that is as good or better than my present one.		
External information channels	the Internet	The information from the Internet can trigger my fears.
	People around	Rumors and information from people around me can trigger my fears.
	News media	The information from the news media can trigger my fears.

## RESULTS

### Descriptive statistic

Table 2 lists the means, standard deviations, minimum and maximum among variables in the experiment. Significantly, the mean of digital literacy is just above 60, and the standard deviation of digital literacy is high as for the four dimensions, the mean of "Ability to Create Digital Content to Acquire Resources" is much lower than other dimensions, while the standard deviation of "Digital Social Ability" is much higher compared with the others. Also, we found that the mean of "Market Competition Fear" is above 3, which means the market competition fear did exist. Thus, H1 was supported.

Table 2: Means, standard deviations, minimums, and maximums.

Variables	M	SD	Min	Max
Digital Literacy	61.23	16.75	20	98
DL <sub>1</sub>	20.32	5.14	5	25
DL <sub>2</sub>	16.63	7.12	5	25
DL <sub>3</sub>	9.65	5.43	5	25
DL <sub>4</sub>	14.63	4.71	5	25
Market Competition Fear	3.33	1.07	1	5
Internet Information	2.67	1.19	1	5
People around	2.97	1.16	1	5
News media	2.96	1.22	1	5

Note: DL<sub>1</sub>= "Fundamental of Digital Ability." DL<sub>2</sub>= "Digital Social Ability." DL<sub>3</sub>= "Ability to Create Digital Content to Acquire Resources." DL<sub>4</sub>= "Ability to Operate with Digital Technology."

### Regression Analysis

#### Internal factors on market competition fear.

First, we took market competition fear as the dependent variable. Then, digital literacy and its dimensions were respectively

introduced into the regression equation as independent variables. According to Model<sub>1</sub> in table 3, Digital Literacy ( $\beta=-0.475$ ,  $p<0.001$ ) has a significant negative effect on market competition fear. So that the H2 was supported. As for the other four dimensions, it is clear to see in Model<sub>2</sub> that digital social ability (DL<sub>2</sub>,  $\beta=-0.157$ ,  $p<0.1$ ) and ability to create digital content to acquire resources (DL<sub>3</sub>,  $\beta=-0.306$ ,  $p<0.001$ ) both have a significant negative effect on market competition fear. Thus, H1b and H1c were supported. This suggests that if individuals can constantly obtain resources and keep well in contact with customers, counterparts, and suppliers, their job security can be enhanced, which may reduce individuals' market competition fear.

However, according to the regression result, the effect of fundamental digital ability (DL<sub>1</sub>) on market competition fear was not significant, so was the ability to operate with digital technology (DL<sub>4</sub>). The result shows that whether individuals have the ability to use digital devices and apps cannot contribute to the operation. That's mainly because this ability is basic in the digital era, which is not a part of the core competitiveness of operators. On the other hand, due to the small scale, the use of digital technology for inventory and financial management makes little sense. There are few demands for the operators to keep accounts electronically. Meanwhile, almost all the greengrocers collected money through Alipay and WeChat Pay, which means the differences of operation among greengrocers are small, and the ability can hardly improve their competitiveness.

#### **External factors on market competition fear.**

In Hypotheses 3, we argued that information from different external channels could affect market competition fear. In Model<sub>2</sub>, the information from people around ( $\beta=0.300$ ,  $p<0.001$ ) has a significant positive impact on market competition fear. Thus, H3b was supported. However, news media ( $\beta=-0.272$ ,  $p<0.05$ ) has a significant negative impact on market competition fear, which means the information from news media reduces the fear of market competition. We argued that news media acts as a bridge between the government and the public and has strong credibility, which is fair and objective. Thus, news media can effectively reduce the fear of competition fear and ensure the stability of social order.

However, the result shows that Internet information does not have a significant effect on market competition fear. Thus, hypothesis 2a was rejected. We believed that most greengrocers use the Internet for entertainment instead of searching for information, and they obtained little information about the community group buying market from the Internet. So, the information from the Internet cannot influence their feelings of fear.

Table 3: Results of regression analysis of variables

Dependent Variable	Market Competition Fear	
	Model <sub>1</sub>	Model <sub>2</sub>
Model		
Independent Variable		
Digital Literacy	-0.475***	-
DL <sub>1</sub>	-	0.028
DL <sub>2</sub>	-	-0.157*
DL <sub>3</sub>	-	-0.306***
DL <sub>4</sub>	-	-0.080
Internet Information	0.060	0.039
People Around	0.275***	0.3***
News Media	-0.233**	-0.272**
Model Statistics		
Adjusted R <sup>2</sup>	28.50%	27.10%
F	20.16	11.18

Note: \* $p < .1$ ; \*\* $p < .05$ ; \*\*\* $p < .01$ .

DL<sub>1</sub>= "Fundamental of Digital Ability." DL<sub>2</sub>= "Digital Social Ability." DL<sub>3</sub>= "Ability to Create Digital Content to Acquire Resources." DL<sub>4</sub>= "Ability to Operate with Digital Technology."

## CONCLUSION

This paper focused on the market competition fear caused by technological innovations in the digital transformation. Based on the Internet giants' entry into the community group buying market of fresh food products, we explored the objective existence of market competition fear in the digital transformation. Firstly, the levels of digital literacy influence the market competition fear. The higher level of digital literacy leads to lower market competition fear. For internal factors, digital literacy plays an important role in overcoming the market competition fear caused by digital transformation. However, not all the abilities related to digital literacy have a significant effect. The basic digital knowledge and ability cannot help market participants to resist the fear, but the digital social ability and the ability to create digital content to obtain resources can effectively reduce the fear. This means that operators who use social networks wisely can be more competitive. What's more, for the external factors, individuals can easily be influenced by the information and rumors from people around and intensify the feeling of fear. Although the information from the Internet can barely influence the operators in the food market, the news media, as a reliable source of information, spreading information can help reduce fear. Hence, we concluded that digital transformation induces the market competition fear. Meanwhile, digital literacy and external information channels have a positive influence on the market competition fear.

### Theoretical Implication

This paper explored the effect of digital literacy and external information channels on market competition fear. Firstly, the result confirmed that digital transformation induces the fear of job losses and the worry about finding a new job (Kharlamov *et al.*, 2021). People have difficulties in adopting technological innovations in terms of accelerating digital transformation. Meanwhile, we coined the term market competition fear based on prior researches, which refers to the fear in the market caused by technical competition in digital transformation.

Secondly, the study also expanded the effect of digital literacy on individuals. Prior researches have focused on exploring the influence mechanism of digital literacy on behaviors (Ball & Webster, 2020; Chung *et al.*, 2015). However, this paper considered digital literacy as an internal factor and discussed the impact of digital literacy on negative emotions caused by technological innovations, which filled the research gap about digital literacy of operators.

### Managerial Implication

Nowadays, many companies have been trying to apply digital technology to strengthen the resilience of enterprises in the post-epidemic era. The results of this paper also have positive implications for preventing and resolving market competition fear caused by digital transformation. Firstly, the integration of new technologies and traditional industries may cause overall and chain risks in society, such as market fear caused by fears of large-scale unemployment and resource misallocation. More attention should be paid to such issues, and the expansion of capital scale should be limited in order to prevent monopolies, which can better level the playing field for market participants.

Secondly, the digital abilities of operators need to be improved according to the characteristics of a business. It is obvious that different types of the job require different abilities. Only cultivating the abilities related to the operation can truly help the operators gain the confidence to confront the challenges of their jobs. Take the food market as an example. It is hard for self-employed operators to defeat the Internet giants if they only improve some basic digital abilities, such as using smartphones and apps. Only by cultivating digital abilities related to operation can it make the operators more competitive. Thus, a vocational digital competency training program should be established to help practitioners improve their digital competitiveness, which must be led by the government, including how to obtain customers and sources of goods through digital channels and how to use social platforms to maintain customer relationships.

Thirdly, the lack of understanding of new technologies can easily turn into misunderstandings, and misinformation will be spread through various channels, triggering fear. When facing rumors about new technologies, it is necessary to use the official news media to stop the rumors from spreading further. Although there are many information channels like social platforms these days, official media still occupies an important place. The official news media must dispel rumors and transmit correct information in time, shape public opinions, and play a role in maintaining the stability of society. In addition, the mainstream news media are responsible for helping market participants understand the impact of technological progress on the market and to help innovation-driven development.

### Limitation and Further Research

Although this study confirmed that digital literacy and different information channels could affect market competition fear, we believe that this study has some limitations. First, there are a few types of research focused on the digital literacy of operators and market competition fear. As a result, it is difficult to develop the scales of operators' digital literacy and market competition fear in this paper based on mature scale, and the validity of the scale needs to be strengthened. Therefore, we will keep up to date with the latest researches about digital literacy and market competition fear in the future and perfect the measurement frameworks of operators' digital literacy and market competition fear. On the other hand, we think the amount of data in this paper can be expanded. This study believed that Internet information would negatively affect the market competition fear. The more frequently people are exposed to the Internet, the easier it is to induce fear. But this research did not get significant data results. It may be because the operators in the food market seldom keep up with the news through the Internet. We believe that more participants can be invited to participate in our experiment in the future. At the same time, we can add moderator and mediator to further test the influence of variables on the model, such as the operator's revenue and operating years.

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## The Effect of Motives on Enterprise Social Network Usage

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### ABSTRACT

Enterprise Social Networks (ESNs) have brought revolutionary changes to business organizations as they offer enormous potential to enhance collaboration, interaction, innovation, and efficiency. However, despite these benefits, many organizations have failed to encourage their employees to actively engage with ESNs, making their investment decisions questionable. Therefore, this study focused on examining the motivations to use ESNs. A comprehensive literature review was conducted to identify the gratifications motivating the employees to use ESNs. Accordingly, information sharing, self-documentation, entertainment, and social interaction were identified as the gratifications driving the employees to use ESNs at work. Data were collected from 146 employees in the software industry who use ESNs at work through an online survey-based structured questionnaire, and data analysis was performed using partial least square based structural equation modeling using SmartPLS. The results revealed that amongst the four gratifications examined in this study, information sharing, self-documentation, and social interaction have positive and significant effects on ESN use. The findings of the study have both theoretical and practical implications. Because the studies examining the gratifications driving ESN use are scarce, the present study helps to fill the existing knowledge gap in this context. This is especially significant in the Sri Lankan context.

*Keywords:* Enterprise social networks, Gratifications, Uses and gratification theory, Motives, Sri Lanka

### INTRODUCTION

With the competitiveness in the environment, organizations are increasingly investing in creating a corporate culture that enhances communication, employee engagement, employee performance, and knowledge sharing among employees. To assist organizations in achieving these objectives, a new class of information technology, commonly known as Enterprise Social Networks (ESNs), has gained prominence in contemporary organizations. The widespread adoption of social networking sites such as Facebook, LinkedIn, and Twitter among the individuals prompted organizations to use similar systems within the organizations. Accordingly, organizations created Enterprise Social Networks, using social networking platforms within the corporate realm to improve communication among employees. ESNs are being widely utilized by organizations as a digital platform to facilitate internal communications, social interactions, and knowledge sharing within an enterprise. The main motive of deploying ESNs is to provide employees with new ways of communication, collaboration, and creation and to use knowledge to enhance employee engagement and performance within the organization (Osborne & Hammoud, 2017).

Adoption of the ESNs can bring a variety of benefits and opportunities to the organization. Enterprise performance and success are increasingly dependent on the efficiency and quality of internal social interaction platforms. However, despite the high level of proliferation, many organizations have failed to successfully implement ESNs within the organization and to encourage the adoption of ESNs among the workforce (Alarifi *et al.*, 2016). Recent studies have predicted that 80% of ESN initiatives may fail to leverage and materialize the intended benefits due to underutilization and lack of adoption (Mann *et al.*, 2012 cited in Chin *et al.*, 2015). According to Liu and Bakici (2019), the majority of the ESNs implementation projects fail during the first six months of the implementation. They identified a possible reason for failure as only a few employees actively use ESNs by accessing and sharing content. They also stated that the business value of ESNs cannot be realized without active employee engagement. In order to increase employees' active usage of ESNs, it is essential to identify different motives driving employees to use ESNs. Even though the effect of motivation has been examined in relation to the other communication media, limited studies have been conducted in identifying the motivations to use ESNs. Further, when examining the limited literature available relevant to ESN use, it is apparent that the findings are not consistent. Therefore, there is a real practical and knowledge gap that needs to be further explored.

The varied findings in the previous research may have emerged due to the cultural differences between different contexts. Also, factors like attitude and individual differences among different workgroups may also lead to different findings. Therefore, it is difficult to generalize findings made in other contexts to the Sri Lankan context. Thus, it is apparent that there is a clear research gap in relation to the use of ESNs in the context of Sri Lanka. Therefore, in order to fill the identified research gap, the study focused on identifying different motives and their influence on ESN usage in the Sri Lankan context. The researcher wanted to achieve two objectives from this study. The first objective was to identify the different motives affecting the usage of ESNs. The second objective was to assess the effect of those factors on ESN usage.

## THEORETICAL FOUNDATION AND HYPOTHESES DEVELOPMENT

### Enterprise Social Networks

Enterprise Social Networks can be defined as “ Web-based platforms that allow workers to (1) communicate messages with specific coworkers or broadcast messages to everyone in the organization; (2) explicitly indicate or implicitly reveal particular coworkers as communication partners; (3) post, edit, and sort text and files linked to themselves or others; and (4) view the messages, connections, text, and files communicated, posted, edited and sorted by anyone else in the organization at any time of their choosing” (Leonardi *et al.*, 2013, p. 2). Ellison *et al.* (2015) defined ESNs as a set of technologies that include the basic features of social networks but are implemented within an organization, are permitted by management, and have the capacity to limit membership to specific individuals of a selected organization. ESN is identified as a subset of Enterprise 2.0, which refers to the use of social software such as social networking sites, blogs, wikis, microblogging, and social bookmarking services within enterprises (Mäntymäki & Riemer, 2016). An increasing number of organizations are adopting social network-based applications such as IBM connection, Yammer, Jive, or proprietary solutions that integrate social media technologies such as wikis, blogs, and social networking services into a single platform facilitating internal communication (Kuegler *et al.*, 2015).

### Uses and Gratification Theory

Uses and Gratification theory was originally developed in 1940 and used to examine the satisfaction of radio listeners (Liang *et al.*, 2020). This theory has also been applied in the context of different types of print media such as newspapers, magazines, and television (Dunne *et al.*, 2010). As cited by them, users are capable of understanding their own needs and, as a result, selecting the appropriate media. This theory investigates the gratifications or benefits that draw audiences to various media platforms and the types of content that meet their social and psychological needs (O’Donohoe, 1994 cited in Dunne *et al.*, 2010). The goal of the uses and gratifications theory is to better understand why individuals choose certain types of media as well as to investigate the diverse motives of individuals when interacting with media (Hossain, 2019). The emergence of new digital technologies has re-energized the use of the Uses and Gratification theory for the new media. Therefore, this theory has been widely adopted with new communication media such as social networks sites, mobile social network sites, online games, and virtual communities (Hossain, 2019). When considering the ESNs, employees may enjoy the process of utilizing ESNs, the quality of content and information offered via ESNs, or the social engagement enabled with others in the organization (Liu & Bakici, 2019). Such gratifications received from the use of ESNs may encourage people to actively use ESNs. Therefore, in identifying what motivates employees to use ESNs, this theory can be best applied (Liu *et al.*, 2010; Smock *et al.*, 2011; Alhabash *et al.*, 2014; Alhabash & Ma, 2017; Gan & Li, 2018; Hossain, 2019).

### Gratifications and Enterprise Social Network Usage

One of the objectives of this study is to determine the different gratifications that drive individuals to use ESNs. Since there were different studies conducted in order to identify the different gratifications or motives that directed people to use different media, the researcher adopted a systematic approach to identify the most suitable gratifications for ESN usage, which can then be used to develop a justifiable conceptual framework. Accordingly, the researcher referred to thirteen research articles that have examined the relationship between gratifications and ESN usage and identified fourteen gratifications that can motivate media usage. Out of the fourteen gratifications identified, the four most used gratifications were selected for this study.

### Hypotheses Development

#### *Information sharing and ESN usage*

Information sharing can be defined as the extent to which the contents were exchanged, distributed, and received by the user on media (Kietzmann *et al.*, 2011). In this study, information sharing is regarded as posting the contents and commenting on the contents using enterprise social networks. As cited by Laitinen and Sivunen (2021), in organizations, information sharing via ESNs is critical since it permits members to stay informed about organizational issues as well as share and preserve knowledge in an accessible platform. According to Liu and Bakici (2019), information sharing has a significant influence on ESN usage. Therefore, based on the existing literature, it can be identified that there is a positive effect of information sharing on ESN usage. Hence, the following hypothesis was proposed.

H1: There is a positive effect of information sharing motive on ESN usage.

#### *Self- documentation and ESN usage*

Social media, especially blogs, can be used for the purpose of self-documentation as it can be used to document the own life, activities, and events of the users (Nardi *et al.*, 2004). Similarly, ESNs allow the employees to document their daily activities, such as what projects they are working on, what the progress is so far, and so on. As cited by Liu and Bakici (2019), the persistent affordance associated with ESNs allows employees to document their activities similar to a blog. According to the studies conducted by Liu *et al.* (2016) and Liu *et al.* (2010), it can be identified that self-documentation creates a significant influence on ESN usage. Hence, the following hypothesis was proposed.

H2: There is a positive effect of self-documentation motive on ESN usage.

#### *Entertainment and ESN usage*

According to Whiting and Williams (2013), entertainment refers to the use of media to deliver enjoyment. A study done by Liu and Bakici (2019) mentioned that the employees are encouraged to participate in such internal corporate communities facilitated via ESNs in order to have fun and enjoyment. According to Leftheriotis and Giannakos (2014); Liu and Bakici (2019), entertainment has a positive influence on the usage of ESN. Hence, the following hypothesis was proposed.

H3: There is a positive effect of entertainment motive on ESN usage.

#### ***Social interaction and ESN usage***

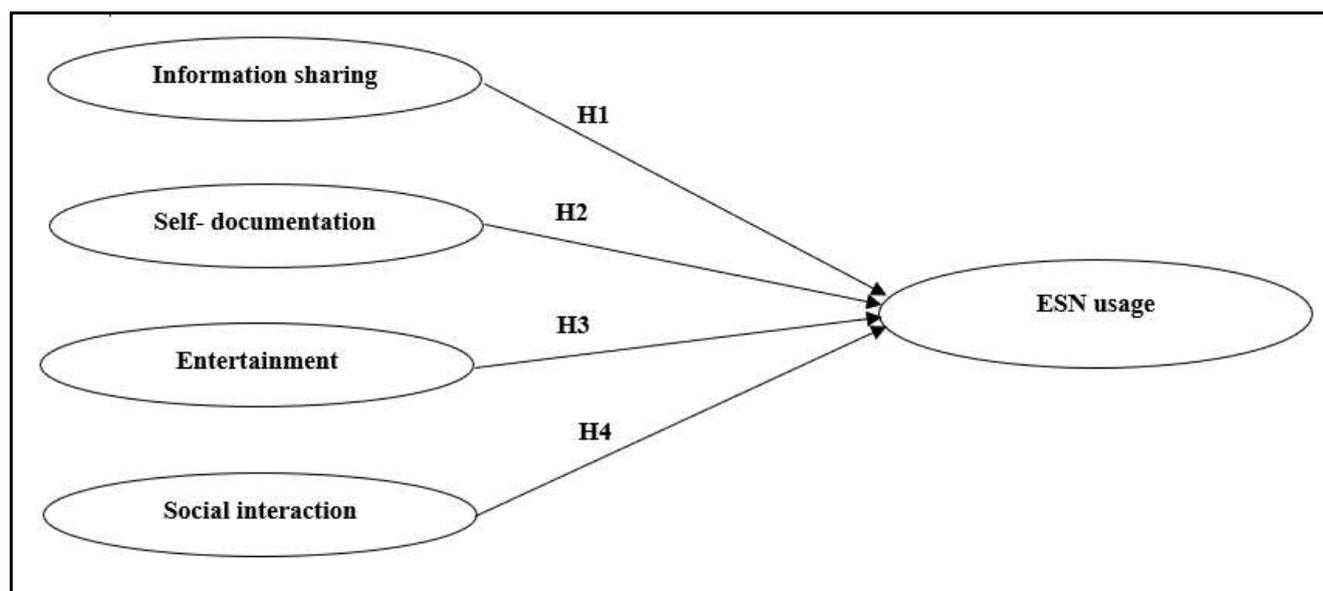
Social interaction can be defined as the use of media to communicate and interact with others (Whiting & Williams, 2013). Social media develop new opportunities for social interactions via chat, instant messaging, posting, rating, and commenting, etc. (Liu & Bakici, 2019). According to Leonardi et al. (2013), ESNs contribute to the development of social capital within the organization as it allows employees to know what others are doing and also to easily establish new connections with other employees. Prior studies have empirically validated the important role played by social interactions in influencing the use of enterprise social media (Whiting & Williams, 2013; Liu & Bakici, 2019). Hence, the following hypothesis was proposed.

H4: There is a positive effect of social interaction motive on ESN usage.

## **RESEARCH METHODOLOGY**

### **Conceptual Model**

For the purpose of this study, the researcher decided to select the most cited four gratifications as gratifications that motivate employees to use ESNs. The selected gratifications have been used by more than 45% of the previous researchers; hence it justifies the importance of these variables. These gratifications include information sharing, self-documentation, entertainment, and social interaction. Based on that, the conceptual model depicting the relationships between these gratifications and ESN usage was developed (Refer to Figure 1).



*Source:* This study.

Figure 1: Conceptual Model.

### **Sample**

This study adopted both purposive sampling and snowball sampling as the sampling technique. In order to be a part of the study sample, the respondents needed to satisfy two criteria; respondents needed to use ESNs at work, and they should work in the software industry. On that basis, the researcher can justify the use of purposive sampling as a sampling technique for the study. On the other hand, as the researcher does not have information on the companies using ESNs, the researcher used known contacts to identify the organizations using ESNs first. Then an email invitation was sent to the contact person asking him or her to distribute the questionnaire among other colleagues in the respective organization. This process was repeated until the required number of responses were gathered. Consequently, the study employed a snowball sampling technique as well. Here, the sample was selected from the software industry due to several reasons. One is that employee collaboration and interaction are of paramount importance in the software industry. Further, it was deemed that the widespread use of ESNs in the software industry would lead to more realistic results from the present study.

### **Instrument Development**

The questionnaire method was employed in order to collect data from the target sample. The questionnaire consisted of 3 sections. The first section covered the demographic questions, which included gender, age of respondent, functional area, job

level, type of ESN used, and employees' experience with the ESNs. The second section of the study focused on the four gratifications that induce the employees to use ESNs, and the third section consisted of the items to measure ESN usage. The items to measure the constructs were adopted from the previous literature, and each item was measured based on a seven-point Likert scale ranging from strongly disagree to strongly agree. Once the structured questionnaire was developed, it was pretested first using two academics and a few experts from the industry. Next, a pilot study was done using 20 respondents from the industry. Both the pretesting and pilot testing resulted in modifying and deleting several items from the original format of the questionnaire to improve the clarity of the questionnaire items and also to make them more suitable for the Sri Lankan context.

### Data Collection

In order to collect the data, a questionnaire was prepared as an electronic questionnaire using google forms. The online questionnaire invitation was distributed among the selected employees from the software industry who have experience with ESNs. The data collection process was continued for two months, and a hundred and sixty-eight (168) responses were received. Out of all the responses, there were twenty-two (22) respondents who did not have experience with ESNs. Since the sample had to consist of employees in the software companies who use ESNs at work, those responses were dropped from further analysis. This left the researcher with a total of one hundred and forty-six (146) responses.

### Method of Data Analysis

For the purpose of data analysis, the researcher utilized two statistical software, namely, Statistical Package for the Social Sciences (SPSS) and SmartPLS. SPSS was used for the purpose of data cleaning, demographic analysis, descriptive statistical analysis, and multivariate assumptions testing. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used for comprehensive data analysis.

## DATA ANALYSIS AND FINDINGS

As a part of multivariate analysis, the normality and multicollinearity assumptions were tested. The normality was tested using Skewness and Kurtosis (Hair *et al.*, 2014). The results of the analysis indicated that the skewness value of all items was ranged between -3 to +3, while the kurtosis values of all items ranged between -10 to +10, thereby indicating the normal distribution (Kline, 2016). Multicollinearity of the variables was tested using the Variance Inflation Factor (VIF). The results of the study indicated that the VIF values of all the variables are below 5. Hence there is no issue in relation to multicollinearity (Sekaran and Bougie, 2016).

### Respondents' Profile

The respondent's demographic characteristics indicated that 57% of the respondents were males while 43% were females. The majority of the respondents (72%) were from the age category of 26-35 years. Also, a higher percentage of the respondents were from the middle-level management (39.7%) and the operational level employees (38.4%). Further to this, the majority of the respondents were from the information technology (79.5%) division. It was also observed that 35.4% of the respondents were using Workplace by Facebook, 28.7% respondents were using Yammer, and 25% of respondents were using Slack. Further, it was indicated that the majority of respondents (58.1%) had 3-5 years of experience with ESNs, and 42.5% of respondents had 1-3 years of experience with ESNs.

### Reliability and Validity

Reliability can be identified as the degree to which the observed variable measures the true value (Hair *et al.*, 2019). According to Hair *et al.* (2019), composite reliability and Cronbach's alpha are considered as measures of internal consistency. The acceptable level of composite reliability is 0.7 or above (Hair *et al.*, 2011), while the generally accepted lower limit for Cronbach's alpha is 0.70 (Hair *et al.*, 2019). However, the Cronbach alpha values greater than 0.95 is not good as it may indicate the redundancy of questionnaire items (Hulin *et al.*, 2001; Ursachi *et al.*, 2015). According to Table 1, the Composite reliability and Cronbach's alpha values of all four constructs were above 0.70. Therefore, the internal consistency reliability of the constructs was established.

According to Hair *et al.* (2019), validity can be defined as the extent to which the indicators of a construct jointly measure what they are supposed to measure. This was ensured using content validity and construct validity. In this study, constructs were developed using the existing literature, and also the independent and dependent variables were operationalized referring to the previous literature. Therefore, the content validity is satisfied.

Construct validity can be measured using convergent validity and discriminant validity measures. According to Hair *et al.* (2014), convergent validity can be measured using Average Variance Extracted (AVE). The general rule for an acceptable AVE is 0.5 or higher (Hair *et al.*, 2019). According to Table 1, the AVE values of all the constructs are greater than 0.5. Thus the convergent validity is established. Discriminant validity was tested using the Fornell-Larcker criterion. In order to ensure the discriminant validity, the square root of the AVE value of each construct should be higher than its highest correlation with any other construct. As depicted in Table 2, the square root values of the AVE of each construct are higher than the correlation with other constructs. Therefore, the discriminant validity is established.

Table 1: Summary of reliability and convergent validity results.

Construct	Cronbach's Alpha	Composite Reliability	AVE
Entertainment (E)	0.939	0.953	0.804
ESN usage (EU)	0.928	0.946	0.779
Information sharing (IS)	0.950	0.964	0.870
Self-documentation (SD)	0.915	0.946	0.854
Social interaction (SI)	0.949	0.959	0.796

Source: Survey data

Table 2: Discriminant validity results.

	E	EU	IS	SD	SI
Entertainment (E)	<b>0.897</b>				
ESN usage (EU)	0.436	<b>0.882</b>			
Information sharing (IS)	0.535	0.579	<b>0.933</b>		
Self-documentation (SD)	0.488	0.540	0.583	<b>0.924</b>	
Social interaction (SI)	0.650	0.627	0.631	0.530	<b>0.892</b>

Source: Survey data

### Testing of Hypotheses

The main objective of this study was to identify what gratifications affect ESN usage. Following the PLS-SEM, the path coefficients and the significance of the relationships were assessed using the bootstrapping results. The results are shown in Table 3.

Table 3: Summary of hypotheses testing.

Hypothesis	Path	Path coefficient	T Statistic	P Value	Decision
H <sub>1</sub>	IS → EU	0.223	2.102	0.036	Supported
H <sub>2</sub>	SD → EU	0.221	2.858	0.004	Supported
H <sub>3</sub>	E → EU	-0.054	0.700	0.484	Not Supported
H <sub>4</sub>	SI → EU	0.402	3.497	0.000	Supported

Source: Survey data

As depicted in Table 3, the path coefficients for information sharing, self-documentation, and social interaction are positive and significant at a 95% confidence level ( $p < 0.05$ ). This indicates that Information Sharing, Self-documentation, and Social Interaction have positive and significant effects on ESN usage. Therefore, hypotheses H<sub>1</sub>, H<sub>2</sub>, and H<sub>4</sub> are accepted. However, it is apparent that Entertainment has no significant effect on ESN usage ( $p > 0.05$ ). Thus, H<sub>3</sub> was rejected.

Once the significance of relationships between variables was tested, the Coefficient of determination (R<sup>2</sup>) was used to measure the proportion of the variance in the endogenous variables that is explained by the predictor constructs (Hair *et al.*, 2019, p.760). The analysis reported an R<sup>2</sup> value of 0.479 and an adjusted R<sup>2</sup> value of 0.460, which indicates that 46% of the variance in ESN usage is explained by Information sharing, Self-documentation, Entertainment, and Social interaction. This indicates that there is an explanatory power closer to a moderate level in the conceptual framework depicted in Figure 1 above (Hair *et al.*, 2011).

### DISCUSSION

The analysis of the study was undertaken to achieve the research objectives set at the beginning of the study. In order to achieve the first objective, the researcher carried out an extensive literature review which was based on the Uses and Gratifications theory. This resulted in the identification of four gratifications, namely, Information sharing, Self-documentation, Entertainment, and Social interaction.

In order to achieve the second objective of the study, four hypotheses were proposed and tested. The results of the analysis indicated H<sub>1</sub> was supported, indicating that information sharing has a positive and significant effect on the employees' use of ESNs at work. This finding was consistent with the previous studies of Smock *et al.* (2011); Whiting and Williams (2013); Alhabash *et al.* (2014); Ali-Hassan *et al.* (2015); Alhabash and Ma (2017); Gan and Li (2018); Liu and Bakici (2019); Meske *et al.* (2019); Hossain (2019). The significant effect of information sharing on ESN usage can also be explained by identifying how ESNs function within the organization. According to Liu and Bakici (2019), in general, ESNs incorporate different features of social networks such as blogging, posting, and chatting, which allow employees to create content and share those contents with others in their organization. Therefore, employees consider ESNs as a convenient medium that satisfies the information-sharing motive (Leonardi *et al.*, 2013). Further, it was identified that the employees' desire to share required information more instantly with others might enhance their engagement with the ESN.

According to the results, H<sub>2</sub> was supported. Therefore, it indicates that there is a significant positive impact of self-documentation motive on ESN usage. This result is also confirmed by several previous empirical studies done by Liu *et al.* (2010); Alhabash *et al.* (2014), Liu *et al.* (2016); Alhabash and Ma (2017). As cited by Liu and Bakici (2019), using the features such as blogging associated with ESNs, employees can create posts and documents related to their daily activities and track their working progress. The employees can document their daily routines, such as what they are currently doing using the ESN platform. When ESNs are associated with the facilities which fulfill the employee's motivation of self-documentation, it will improve the ESN usage by employees (Liu & Bakici, 2019).

The findings revealed that H<sub>3</sub> was not supported. Hence, it can be inferred that the entertainment motive does not have a significant influence on ESN usage. This finding is consistent with several past studies conducted by Liu *et al.* (2010), Liu *et al.* (2016), Sun *et al.* (2020). According to Sun *et al.* (2020), even though employees seek those entertainment-related features of ESNs to release their stress while working, but due to their responsibility for work, they may be compelled to focus back to work after a short break rather than spending too much time with ESNs pursuing entertainment. Further, employees may not use features of entertainment as it is governed by the organization. Rather, they may prefer to use other public social networks as their activities are not monitored and controlled, and they may be able to get engage with more interactive content that is entertaining. The above-explained reasons would have contributed to the fact that entertainment motive does not have a significant effect on the use of ESNs in the present study.

Finally, the analysis revealed that H<sub>4</sub> was supported, indicating that there is a positive and significant effect of social interaction motive on ESN usage. Findings of the previous research done by Smock *et al.* (2011); Whiting and Williams (2013); Alhabash *et al.* (2014); Ali-Hassan *et al.* (2015); Chiu and Huang (2015); Alhabash and Ma (2017); Liu and Bakici (2019); Meske *et al.* (2019); Hossain (2019) are consistent with the findings of this study. According to Liu and Bakici (2019), ESNs are interactive in nature as they incorporate social networking features that allow employees to build their personal profiles, interact with other employees and build social capital. It was cited by these authors that it is easier to create social capital when people know about their coworkers and what they are doing. When more interactions are built with coworkers, it makes it easier to establish new connections with people (Leonardi *et al.*, 2013).

### **THEORETICAL AND MANAGERIAL IMPLICATIONS**

This study contributes to the existing knowledge by applying the Uses and Gratifications Theory to the enterprise social networks context. This provides an opportunity to analyze the usage of ESNs purely from a motivational perspective. Also, exploring and validating four constructs (information sharing, self-documentation, entertainment, and social interaction) which have been cited most by the previous researchers, contributes to the existing literature. This study presented a unique theoretical framework depicting the relationships between different gratifications motivating the employees to use ESNs and ESN usage. This study fills an important research gap in the domain of using ESNs in the Sri Lankan context as there was a limited number of research conducted on the use of ESNs. Finally, this study can induce future researchers, especially in developing nations, to examine the use of ESNs due to the important role played by Enterprise Social Networks in today's organizations.

This study also provides several insights to the practitioners and organizations who have already adopted ESNs and who intend to adopt them in the future. First, with the implementation of ESNs, one of the main challenges that managers face is motivating and encouraging their employees to use ESNs for their work. The literature review revealed four important motives established through prior research, which can be focused on by organizations to induce employees to increase the use of ESN.

Especially, the findings revealed that information sharing, self-documentation, and social interaction have positive and significant effects on ESN usage. With this knowledge, organizations can especially focus on improving the capabilities and interests of employees in those three areas to significantly increase the use of ESNs at work, giving more benefits to the organization. Further, creating a more collaborative and interactive organizational culture within organizations can increase the necessity for areas like information sharing and social interaction, which in turn can drive ESN usage.

Since the findings revealed that the most critical gratifications that induce employees to use ESNs are information sharing, self-documentation, and social interaction, ESN developers can focus on enhancing the capabilities and associated features of those three aspects leading to higher use of ESNs by the employees.

## CONCLUSION

This study focused on identifying the gratifications that affect ESN usage. Therefore, a systematic literature review was conducted in order to identify the gratifications/motives affecting ESN usage. In identifying these gratifications, the Uses and Gratifications theory was used as the primary theory. Amongst the many gratifications identified through the previous studies, the researcher identified information sharing, self-documentation, entertainment, and social interaction as the most cited by previous researchers. Consequently, they were used as the specific gratifications affecting the ESN usage for the present study. The conceptual model and hypotheses were developed based on these four gratifications.

PLS-SEM was used to test the hypotheses. The analysis revealed that information sharing, self-documentation, and social interaction motives significantly affect ESN usage, while entertainment does not have a significant effect on ESN usage.

## LIMITATIONS AND FUTURE DIRECTION

This research study consists of several limitations. Data were collected only from the employees working in the software industry. Hence, it affects the generalizability of the findings to other industries. In addition, the smaller sample size too can restrict the generalizability of the results. Also, the study only focused on testing the direct effects between gratifications and ESN usage. However, the possible indirect and mediation effects were not examined in this study.

The findings and the limitations discussed in the study clearly reflect different avenues which can be examined in future research. This study focused only on four factors affecting ESN usage. Future researchers can expand this framework to incorporate more factors. Further, future researchers can examine possible indirect and mediating effects, in addition to the direct effects examined in this study. Rather than focusing on a single theory, future researchers can integrate several theories to identify the factors motivating employees to use ESNs. The motivations identified can differ from industry to industry. Therefore, future researchers can replicate this study in a different industry or conduct a cross-industry analysis and compare the results.

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## The Effect of Transport Amenities on Customer Satisfaction: An Empirical Study from the Online Travel Community

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### ABSTRACT

Few studies thus far have examined add-on services associated with mitigating hotel location disadvantages. Drawing on the Elaboration Likelihood Model, we in this study consider the variety of transport amenities as a peripheral cue and propose an econometric model that explores the impact of the transport amenities on customer satisfaction. We estimate the model using 187447 reviews assembled from a well-known online travel community in China. The results show that the variety of transport amenities has a significant positive impact on customer satisfaction. Furthermore, we find that the travelers' type and transport convenience have a moderating effect on this relationship. From the perspective of the three-factor theory, we further reveal that the transport amenity is a basic factor for business travelers but an excitement factor for leisure travelers. A variety of robustness tests show that the conclusion of this study is robust.

*Keywords:* Transport amenity, elaboration likelihood model, service variety, three-factor theory.

### INTRODUCTION

Location is regarded as one of the most important determinants of customer satisfaction in the hospitality sector (Rhee & Yang, 2015). A hotel owning an ideal location can have privileged access to external resources in this area, bringing potential convenience for customers (Li et al., 2015). Thus, a traveler will consider many factors to ensure a thorough investigation about the convenience of a hotel's location before purchasing (Chou, Hsu, & Chen, 2008). Among these factors, transport convenience has long aroused great interest of researchers (Yang & Mao, 2020; Yang, Mao, & Tang, 2018). On the one hand, greater transport convenience can save time and cost (Canina, Enz, & Harrison, 2005; Yang et al., 2018). On the other hand, greater transport convenience can strengthen the "tourist environmental bubble". The "tourism environment bubble" is similar to a protective wall, which can isolate travelers from the risks and inconveniences caused by the strangeness of the destination (Cohen, 1972).

However, location is a fixed attribute of a hotel, and it is difficult to change once chosen. Even though the location convenience of hotels has received considerable attention before construction, hoteliers still seem to be very passive because of the uncertainty associated with changes in the surrounding environment. Observing hotels in the city of Xiamen, China, Bégin (2000) found that the transition of the CBD and development of new tourist sites during the past two decades had made significant changes to the distribution of hotels. The old core of the city, once preferred by hoteliers, had become phased out. Alternatively, New development of the hospitality industry generated in the area with recreational activities recently opened, and the building of important infrastructures also led to generators of tourism traffic.

Fortunately, hoteliers can cope with this environmental change by providing transport amenities. As a type of add-on service, transport amenities can solve "the last mile" for customers during travel, further improving the perceived transport convenience, enhancing customer experience, and remedying location disadvantages (Yang et al., 2018). As such, the transport amenity is consistently reported by guests as an essential branch of hotel amenities. For example, research among 56,727 travelers commissioned by Booking.com (2017) reported that shuttle/taxi service to the airport/city center and parking were rated the fifth and the sixth most crucial hotel amenity, respectively. In addition, Expedia Group (2020) surveyed 34,000 travelers and reported that parking and shuttle were amenities that mattered for business travelers. In response to the importance of transport amenities, hoteliers always place transport amenities in a prominent position on the hotel reservation page.

Having noted all this, little attention has been paid to the peripheral cues driving customer satisfaction. To our best knowledge, prior studies mainly focused on the impact of central cues (e.g., service quality) on customer satisfaction. This lack of research prevents hoteliers from identifying and proposing well-grounded strategies to offer amenities because most amenities do not need to have too high quality but need to be more diversified in order to meet the taste of different customers. To fill this

important gap, this research is concerned with the variety of transport amenities, and our main research questions are the following: 1) Are the more transport amenities provided, the better? 2) Do hotels in a good location need to provide more transport amenities? 3) When should hoteliers use free pricing, and who is the target of offering transport amenities?

To answer these questions, we collected a data set from Ctrip, one of the most authoritative online travel communities, and the findings of our study have several important contributions. First, our study reveals the usefulness of transport amenities for both hotels with location advantages and hotels with location disadvantages. We find offering more transport amenities can significantly improve customer satisfaction. In addition, we examine travelers' profiles in moderating this relationship. The result indicates that, compared with leisure travelers, business travelers pay more attention to the variety of transport amenities. Our findings also advance the literature by adopting the three-factor theory in this study. We use the variety instead of the rating to represent the evaluation of an attribute and indicate that the transport amenity is a basic factor for business travelers but an excitement factor for leisure travelers. Further, our findings support previous studies about the zero-price effect phenomenon in the hospitality industry.

## LITERATURE REVIEW

### Hotel Attributes and Amenities

Marketing literature defines attributes as multiple dimensions of a product or service. All products and services can be treated as a package of attributes or characteristics that influence consumer choices (Armstrong et al., 2014). When consumers evaluate a product or a service, their choice is primarily driven by the performance of the product or service's attributes (Kucukusta, 2017). Researchers have identified various attributes that impact customers' purchase behavior and determine their satisfaction in the hotel industry, such as location, price, service, amenity, and room cleanliness. (Bi et al., 2020; Han, Hsu, & Sheu, 2010; Kucukusta, 2017; Soifer, Choi, & Lee, 2021; Yang et al., 2018; Ye et al., 2014).

Hotel amenities can be identified as services or products offered to customers as a part of their overall hotel stay and have become one of the essential value creation attributes of a hotel (Kucukusta, 2017). The hotel amenity now covered in academic research can be mainly divided into two categories: in-room amenities and out-of-room amenities. For in-room amenities, researchers suggested that Wi-Fi has the highest important value compared with other amenities (Heo & Hyun, 2015; Kucukusta, 2017), and free charge of it can significantly enhance customers' perceived value and drive their satisfaction (Liu et al., 2020; Soifer et al., 2021). In addition, Masiero, Heo, and Pan (2015) reported that the effect of other in-room amenities, such as telephone services and free mini-bar items, varies from travelers in different contexts. Hotel amenities out of the room, also called property, are generically referred to as facilities, services, and specific hotel policies such as swimming pool, business center, breakfast, and a pet-friendly policy (Kucukusta, 2017). The transport amenity is a vital aspect of hotel amenities out of the room; among them, parking and airport shuttle are the most frequently studied. For example, Liu et al. (2020) showed that free parking positively impacts customers' perceived value. However, this positive effect is attenuated by vertical competition and higher-grade horizontal competition. Kucukusta (2017) reported that airport/local area shuttles rank the second most crucial among price, wireless Internet, breakfast, and quality of coffee/tea. Kim et al. (2017) indicated that free parking and airport shuttle are two decisive factors to predict customer satisfaction, price premium, and revisit intention. Lin (2017) found that low-end hotels will follow high-end hotels to offer add-on services with moderate marginal cost (e.g., airport shuttle) as optional.

Two deficiencies can be recognized in prior studies. First, though existing research has referred to traditional transport amenities such as parking and airport shuttle, there remained a gap in a more detailed guidance strategy for hoteliers to leverage transport amenities. Second, offering transport amenities has endogenous problems because we can never observe a hotel with and without transport amenities simultaneously. Previous studies treated amenities as exogenous or used coarse matching to fix endogenous problems, which would bring potential bias to the research result. Thus, it's necessary to use a more accurate model to remedy the problem.

### Characteristics of Business Travelers

In tourism research, the topic regarding the difference of business travelers' behavior patterns and preferences has long raised great interest (Chu & Choi, 2000; Gundersen, Heide, & Olsson, 1996; Gustafson, 2012, 2014). The poor sleep quality, busy schedule, traveling alone and limited opportunities to go sightseeing are regarded to be the potential reasons for shaping their common characteristics (Burkholder et al., 2010; Chen et al., 2018; Medina-Muñoz, Medina-Muñoz, & Suárez-Cabrera, 2018; Striker et al., 1999). Many researchers have identified the negative rating bias of business travelers (Banerjee & Chua, 2016; Radojevic, Stanic, & Stanic, 2015). However, Radojevic et al. (2018) found that amenities related to convenience and room can efficiently moderate this adverse effect. Additionally, recent studies also supported business travelers' emphasis on convenience, room, and sleep quality before and after their accommodation experience. For example, Wang et al. (2020) highlighted that business travelers are more impacted by in-room amenities than other travelers. Rhee et al. (2015) showed that sleep and room rank the first and the third most vital attribute for business travelers. Rohani, Aung, and Rohani (2017) indicated that business travelers would prefer a hotel with more business facilities, for example, speedy check-in/out procedure, wake-up call service, airport service, etc. Yang et al. (2018) presented a result that near metro and freeway can only significantly improve business travelers' customer satisfaction compared with others.

Although prior studies reported some transport amenities (e.g., parking) as antecedents and moderators for business travelers' customer satisfaction (Herjanto, Erickson, & Calleja, 2017; Rohani et al., 2017; Yang et al., 2018), they have focused essentially on the linear (or symmetric) relationship between a single transport amenity and customer satisfaction. It is necessary to take a whole picture about the meaning of this type of amenity for business travelers instead of focusing on a point. We aim to use the variety of transport amenities to expand the research scope and try to investigate the asymmetric relationship between transport amenities and customer satisfaction and examine if this relationship varies from travelers in different contexts.

### **Elaboration Likelihood Model and Customer Service Evaluation**

The Elaboration Likelihood Model (ELM) is a psychological theory that describes the way people process persuasive information, thereby changing their behavior or attitude. ELM is a "dual-process" theory that consists of two routes: the central and the peripheral routes. When using the central route to process information, people will carefully scrutinize the information with more effort spent. In contrast, the peripheral route often relies on superficial and straightforward cues without giving too much effort (Petty & Cacioppo, 1986).

Many scholars have successfully applied the Elaboration Likelihood Model to information processing of online reviews and identified some key characteristics of online reviews related to two routes. Generally, researchers have considered that users processed the online reviews about the quality of products using the central route, while quantity cues and source credibility of electronic word-of-mouth (eWOM) are often processed through the peripheral route (Cheung, Lee, & Rabjohn, 2008; Lee, Park, & Han, 2008; Park, Lee, & Han, 2007; Watts & Zhang, 2008). As such, prior studies mainly focused on information processing during purchase based on ELM (Cao et al., 2017; Li, Zhang, & Han, 2021). Few studies have noticed that customers also use dual routes to process the post-purchase experience. Though service quality as a central cue has been widely identified as a driver of customer satisfaction (Olorunniwo, Hsu, & Udo, 2006; Wang, Lo, & Yang, 2004), little attention has been paid to peripheral factors that change customers' attitudes.

To our best knowledge, limited studies apply ELM in hospitality (Filiari & McLeay, 2014; Hardy, Vorobjovas-Pinta, & Eccleston, 2018; Harris, Taylor Jr, & DiPietro, 2021; Hur et al., 2017; Kang & Namkung, 2019; Leung, Lyu, & Bai, 2020; Li et al., 2017; Lu & Gursoy, 2015; Meng & Choi, 2019). Although the above studies testified to the validity of the ELM in IT adoption, food safety, virtual reality advertising, food O2O commerce, crowdfunding ventures, and location-based service adoption, none were concerned with the process to evaluate hotel stay experience.

### **HYPOTHESIS DEVELOPMENT**

Many researchers have reported that greater service variety will drive customer satisfaction (Carins, Rundle-Thiele, & Ong, 2020; Kwun, Ellyn, & Choi, 2013; Singh, 2004). A high-variety strategy can increase customer satisfaction from three aspects. First, it's more likely for customers to find suitable services at the beginning. Second, it can satisfy customers' need for freshness over time (variety-seeking behavior). Last but not most important, more diversified services can make a good impression on customers through improving perceived variety whether they use it or not. Though prior studies expressed some worries concerning plentiful but similar service options even bring a negative consumption experience (Kahn & Lehmann, 1991), it won't disturb our hypothesis. Transport amenities provided by hotels are very diversified, involving all aspects of public transportation (e.g., airport, station, taxi, bus). Thus, each additional transport amenity will significantly increase customer satisfaction through enhancing perceived variety. Therefore, we hypothesize the following:

#### **H1. The variety of transport amenities positively affects customer satisfaction.**

In addition, transport convenience has become a critical dimension of hotel location satisfaction. Transport convenience refers to how easy it is for customers to leave and return to the hotel using local transportation. Various transport amenities can hugely make up for hotels' location disadvantage (Yang et al., 2018). Even for hotels with high transport convenience, transport amenities can bring customers a more comfortable experience by offering customizing services and improving perceived variety. Therefore, we hypothesize the following:

#### **H2. For hotels with high or low transport convenience, more various transport amenities significantly improve customer satisfaction.**

Prior studies found that business travelers always own a stressful schedule (Doyle & Nathan, 2001; Espino et al., 2002; Gustafson, 2012, 2014; Unger, Uriely, & Fuchs, 2016) and have feelings of disorientation, loneliness, and isolation (Cohen & Gössling, 2015). A more convenient hotel can better support their work-related obligations and reduce their negative emotions; thus, many prior studies have found that business travelers would emphasize convenience in their trips. For example, Chu et al. (2000) found that "convenience for the business" ranges highest in the importance of a group of American business travelers. Yavas and Babakus (2005) indicated that business travelers view convenience as the second most crucial attribute, second only to general facilities. Radojevic et al. (2018) showed that the choice of business travelers is often influenced by the transport convenience of the hotel location. Besides the location convenience of the hotel, transport amenities are also a vital aspect to compensate for hotel convenience. Therefore, we hypothesize the following:

H3. Business travelers moderate the positive effect of the variety of transport amenities on customer satisfaction. The positive impact of the variety of transport amenities increases if the traveler is a business traveler.

## METHODOLOGY

### Data and Variables

#### Data source

We obtained our data from ctrip.com. Ctrip is one of China's most popular online travel communities, widely used as a data source in previous studies (Chen et al., 2019). To improve the generalization of our results, we randomly selected 201 hotels in China's top 10 tourism cities voted by travelers. In the hospitality industry, many studies have confirmed that the epidemic will modify consumer behavior (Herédia-Colaço & Rodrigues, 2021; Li, Yao, & Chen, 2021; Zheng, Luo, & Ritchie, 2021). To ensure that consumer behavior does not change severely, in September 2020, we used Python to crawl the reviews one year before the COVID-19, between January 2019 and December 2019, and 201 hotels' profiles. We deleted the reviews from reviewers who traveled alone or booked for others. The main reason is that there is no clear definition of travel context for these two types, which may bring bias to our research. In addition, we deleted the hotels that Ctrip did not show the distance to the nearest metro station. Finally, we got 187447 reviews covering 201 hotels in China's top ten tourism cities. We directly or through calculation got three-dimensional variables of review level, reviewer level, and hotel level.

Table 1: Operationalization and type of variables.

Variable Name	Operationalization
<b>Dependent variable</b>	
Overall_Rating	Overall ratings provided by reviewers on Ctrip
<b>Researched variable</b>	
Trans_Amenity_Vairety	The number of transport amenities provided by the hotel is shown on the hotel reservation page by Ctrip
<b>Moderator</b>	
Business_Traveler	1 if the traveler is a business traveler, 0 otherwise
Transport_Convenience	The centralized distance from the hotel to the nearest metro station
<b>Control variable—review\reviewer level</b>	
User_Grade	Ctrip membership is an advanced contributor program of Ctrip that evaluates reviewers' contributions to Ctrip. Reviewers' membership level appears in the traveler's profile and includes six levels
User_Avatar	1 if the traveler uses his or her own picture as the user avatar, 0 otherwise
Travel_Type	A group of dummy variables of user travel type(business, family, friend, lover)
System_Name	1 if the traveler renames the user name generated automatically by Ctrip, 0 otherwise
Lnreview_Length	The logarithm of the total number of words in a review
Temporal_Distance	Months between the user's check-in date and review's post date
This_Review_Pic_Total	Picture number contains in a review
<b>Control variable—hotel level</b>	
Quality	Combining hotel aspect ratings covering service, environment, cleanliness, facility by principal component analysis
Price_Mean	The average price of all rooms in a hotel
Room_Num	The total number of hotel rooms
Monthly_Neg_Review_Num	Bad reviews are received by the hotel every month
Monthly_Pic_Review_Num	Reviews with pictures received by the hotel every month
Hotel_Grade	Hotel level, a total of 4 levels: Level 2 includes two stars / two diamonds, level 3 includes three stars / three diamonds, level 4 includes four stars / four diamonds, and level 5 includes five stars / five diamonds. Star grade rewarded by professional institutions, diamond grade rewarded by Ctrip, according to the standards of professional institutions
Lnhotel_Num	The logarithm of the number of other hotels within one kilometer around the hotel

**Instrumental variable**

Airport_Distance	The distance from the hotel to the nearest airport
Station_Distance	The distance from the hotel to the nearest express railway station

**Additional analysis**

Free_Trans_Amenity_Variety	The number of transport amenities with a free label provided by the hotels shown on Ctrip
Low_Trans_Amenity_Variety	1 if the hotel doesn't provide any transport amenities, 0 otherwise
High_Trans_Amenity_Variety	1 if the hotel doesn't provide any transport amenities, 0 otherwise
Charge_Trans_Amenity_Variety	The number of transport amenities without free label provided by the hotels shown on Ctrip

**The dependent variable, research variables, and control variables**

On Ctrip.com, each review is attached with an overall rating. Prior studies have widely used the overall rating as a proxy of customer satisfaction (Bulchand - Gidumal, Meli3n - Gonz3lez, & L3pez - Valc3rcel, 2011; Mariani & Borghi, 2018; Ye et al., 2014). Therefore, we used the overall rating as our dependent variable. As for the independent variable, we chose the number of transport amenities to represent the variety of transport amenities. As mentioned in section 3, the increase in service variety needs not only the increase in service quantity but also the increase in service diversity. Transport amenities provided by hotels are very diversified, involving all aspects of public transportation (e.g., airport, station, taxi, bus). So we can use the number of the service to represent the variety of the service directly.

Table 2: Descriptive statistics of all variables.

	Num	Mean	SD	Min	Max
(1) Price_Mean	187,447	830.3	581.5	134.6	6,175
(2) This_Review_Pic_Total	187,447	0.409	1.336	0	9
(3) User_Grade	187,447	1.467	0.633	1	3
(4) User_Avatar	187,447	0.623	0.485	0	1
(5) Room_Num	187,447	196.1	118.4	11	760
(6) Transport_Convenience	187,447	0.605	0.646	-.699	4.270
(7) Airport_Distance	187,447	25.77	14.47	0.450	134.0
(8) Station_Distance	187,447	8.353	9.748	0.140	73.10
(9) Hotel_Grade	187,447	3.989	0.776	2	5
(10) Monthly_Neg_Review_Num	187,447	8.443	10.66	0	142
(11) Monthly_Pic_Review_Num	187,447	27.49	28.37	0	258
(12) Temporal_Distance	187,447	0.813	1.761	0	12
(13) System_Name	187,447	0.317	0.466	0	1
(14) Business_Traveler	187,447	0.369	0.483	0	1
(15) Trans_Amenity_Vairety	187,447	2.866	2.010	0	9
(16) Free_Trans_Amenity_Variety	187,447	1.109	1.249	0	6
(17) Lnhotel_Num	187,447	4.215	0.839	0	4.820
(18) Lnreview_Length	187,447	3.206	1.026	1.099	6.215
(19) Overall_Rating	187,447	4.775	0.563	1	5
(20) Quality	187,447	0.091	1.892	-7.590	2.916
(21) Low_Trans_Amenity_Vairety	187,447	0.075	0.264	0	1
(22) High_Trans_Amenity_Vairety	187,447	0.012	0.109	0	1
(23) Charge_Trans_Amenity_Variety	187,447	1.757	1.713	0	8

This study contains two moderators. The first one is a continuous variable named *Transport\_Convenience*. To measure the transport convenience of a hotel, we followed Yang et al. (2018) to use the distance from the hotel to the nearest metro station.

To avoid multicollinearity, we centralized the metro distance. The second one is a dummy variable representing whether the reviewer is a business traveler, denoted as *Business\_Traveler*.

According to the Elaboration Likelihood Model, customers use the central route and the peripheral route to process the post-purchase information. Thus, we controlled the quality of a hotel using four hotel aspect ratings: *Location*, *Facility*, *Service*, and *Cleanliness*. To avoid redundancy and multicollinearity, we followed Liu et al. (2020) to conduct Principal Component Analysis, which yielded a single quality factor score, denoted as *Quality*. Besides, we also controlled reviewers' personal characteristics, reviews' characteristics, and hotels' characteristics. Table 1 summarizes the Operationalization of variables.

Table 3: Correlation matrix of major variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Airport_Distance	1							
(2) Station_Distance	-0.097***	1						
(3) Trans_Amenity_Vairety	-0.028***	0.282***	1					
(4) Free_Trans_Amenity_Variety	-0.293***	0.367***	0.441***	1				
(5) Overall_Rating	0.000	0.027***	0.009***	0.031***	1			
(6) Business_Traveler	-0.073***	0.027***	0.053***	0.112***	-0.043***	1		
(7) Quality	-0.076***	0.018***	-0.130***	0.014***	0.172***	-0.062***	1	
(8) Transport_Convenience	-0.213***	0.186***	0.219***	0.464***	0.013***	0.069***	0.033***	1

Notes: 1. We report z-statistics in parentheses. 2. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 . 3. Due to page limits, we only report the correlation matrix of eight major variables.

### Empirical model

Consistent with the literature Liu et al. (2020), We use the ordered logistic regression model as the benchmark model. Equation (1) studies the impact of the variety of transport amenities on customer satisfaction. In equation (2), the traveler's profile is a moderator to explore whether business travelers prefer transport amenities to leisure travelers. In equation (3), we change the model from the ordered logistic regression model to the ordinary least squares (OLS) regression model in order to examine margins of basic relationship for specified values of transport convenience. Some arguments may arise from this model change; the explanation can be that the overall rating can be regarded as either continuous or discrete. Therefore, it is reasonable to use the OLS model.

$$Pr(Overall\_Rating_{ijt} = k) = Pr(\lambda_{k-1} < U_{ijt} \leq \lambda_k)$$

$$U_{ijt} = \beta_1 Trans\_Amenity\_Variety_j + \delta_1' \mathbf{X}_j + \delta_2' \mathbf{Y}_i + \delta_3' Travel\_Type_{it} + \theta_1' CityID_j + \theta_2' Time_t + \varepsilon_{ijt} \quad (1)$$

$$Pr(Overall\_Rating_{ijt} = k) = Pr(\lambda_{k-1} < U_{ijt} \leq \lambda_k)$$

$$U_{ijt} = \beta_1 Trans\_Amenity\_Variety_j + \beta_2 Trans\_Amenity\_Variety_j \times Business\_traveler_{it} + \beta_3 Business\_traveler_{it} + \delta_1' \mathbf{X}_j + \delta_2' \mathbf{Y}_i + \theta_1' CityID_j + \theta_2' Time_t + \varepsilon_{ijt} \quad (2)$$

$$Overall\_Rating_{ijt} = \beta_1 Trans\_Amenity\_Variety_j + \beta_4 Trans\_Amenity\_Variety_j \times Service\_Competition_j + \beta_5 Service\_Competition_j + \delta_1' \mathbf{X}_j + \delta_2' \mathbf{Y}_i + \delta_3' Travel\_Type_{it} + \theta_1' CityID_j + \theta_2' Time_t + \varepsilon_{ijt} \quad (3)$$

$\mathbf{Y}_i$  represents a vector of variables controlling various characteristics of reviewers and reviews, including *This\_Review\_Pic\_Total*, *User\_Avatar*, *System\_Name*, *Lnreview\_Length*, *Temporal\_Distance*, and *User\_Grade*.  $\mathbf{X}_j$  represents a vector of variables controlling various characteristics of hotels, including *Quality*, *Price\_Mean*, *Room\_Num*, *Monthly\_Neg\_Review\_Num*, *Monthly\_Pic\_Review\_Num*, and *Hotel\_Grade*. *Travel\_Type* is a category variable. We treat it as a vector of dummies, including *friends*, *business*, *family*, and *lover*. To avoid multicollinearity, we drop *friends* as a control group. When exploring the moderating effect of *Business\_Traveler*, we don't control other travel types in our model. Besides, we control the fixed effects of the city and the month of reviews by introducing two sets of dummy variables, *CityID* and *Time*.

## RESULT

### Descriptive Statistics and Correlations

Table 2 reports the descriptive statistics of the key variables. Table 2 suggests that there are significant variances in the variables. Table 3 shows the correlation matrix of major variables.

Table 4: Ordered logistic estimation results.

	Dependent variable: Overall_Rating	
	(1)	(2)
Trans_Amenity_Variety	0.023*** (7.15)	0.015*** (3.91)
Business_Traveler		-0.179*** (-8.56)
Trans_Amenity_Variety × Business_Traveler		0.026*** (4.44)
Quality	0.179*** (48.60)	0.180*** (48.81)
Price_Mean	0.000*** (4.40)	0.000*** (4.38)
Lnreview_Length	-0.315*** (-53.20)	-0.320*** (-54.12)
This_Review_Pic_Total	0.092*** (19.82)	0.092*** (19.70)
Temporal_Distance	-0.029*** (-6.73)	-0.029*** (-6.75)
User_Avatar	0.261*** (23.11)	0.273*** (24.27)
System_Name	-0.182*** (-15.42)	-0.183*** (-15.44)
Monthly_Neg_Review_Num	-0.010*** (-18.97)	-0.010*** (-18.90)
Monthly_Pic_Review_Num	0.006*** (22.09)	0.006*** (21.66)
Room_Num	-0.001*** (-13.10)	-0.001*** (-13.57)
Lnhotel_Num	-0.022** (-2.53)	-0.021** (-2.35)
Hotel Grade	Yes	Yes
Travel Type	Yes	No
User Grade	Yes	Yes
Time Fixed Effects	Yes	Yes
City Fixed Effects	Yes	Yes
Observations	187,447	187,447

Notes: 1. We report z-statistics in parentheses. 2. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. 3. Due to page limits, some variables are not reported.

### Hypotheses Testing

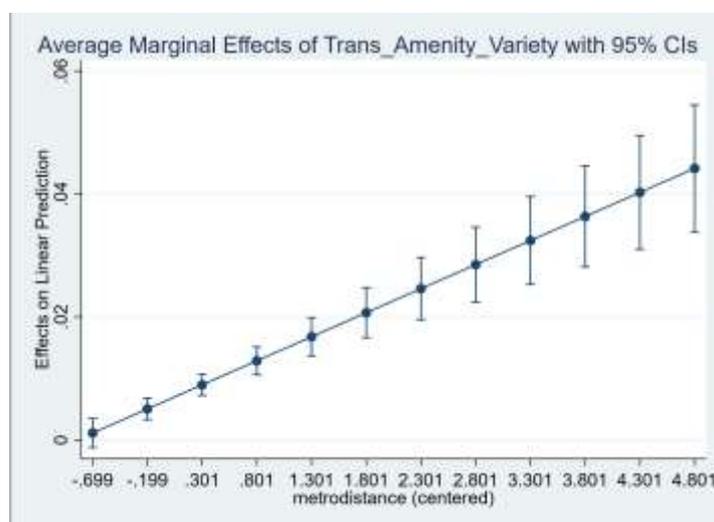
Table 4 presents the order logistics estimation results about the effect of a variety of transport amenities on customer satisfaction and how *Business\_Traveler* affects the strength of this relationship. Following our expectation,  $\beta_1$  on the independent variable is significant and positive for all the models. The outcome indicates that customer satisfaction is higher when hotels offer more transport amenities. Thus, H1 is supported. In Table 4,  $\beta_2$  on the interaction term between *Trans\_Amenity\_Variety* and *Business\_traveler* is positive and significant, which means that as the variety of transport amenities becomes higher, business travelers will feel more satisfied than leisure travelers. Thus, H3 is supported. The result unveils business travelers' preference for convenience, which many prior researchers reported (Radojevic et al., 2018; Yang et al., 2018).

Table 5 presents the OLS results about the role of transport convenience of a hotel in moderating the relationship between the variety of transport amenities and customer satisfaction.  $\beta_4$  on the interaction term between *Trans\_Amenity\_Variety* and *Transport\_Convenience* is positive and significant. That means improving the variety of transport amenities can efficiently mitigate the weaknesses of hotels' transport convenience. To test our hypothesis, we draw the marginal effect of the variety of transport amenities and display it in Figure 1. At each cut point, the coefficient for the variety of transport amenities is positive and significant except for the first point. As the distance from the metro becomes farther, the effect becomes larger, which means hotels with poor locations can achieve better results by providing more transport amenities. Counter-intuitively, hotels with high transport convenience also need to provide more transport amenities.

Table 5: Ordinary least squares estimation results.

Dependent variable: Overall_Rating	
(3)	
Trans_Amenity_Variety	0.024*** (6.62)
Transport_Convenience	-0.065*** (-2.72)
Trans_Amenity_Variety×Transport_Convenience	0.024*** (4.59)
Other Controls	Yes
Hotel Grade	Yes
Travel Type	Yes
User Grade	Yes
Time Fixed Effects	Yes
City Fixed Effects	Yes
Observations	187,447

Notes: 1. We report z-statistics in parentheses. 2. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. 3. Due to page limits, the estimates of some variables are not reported.



Source: This study.

Figure 1: Marginal effects of the variety of transport amenities

Table 6 presents the result for the robustness test of the primary model. We use two replacement models to check out the reliability of the outcome, two-stage least squares regression(2SLS) and Multilevel mixed-effects ordered logistic regression(Meologit). We use the Meologit model to control the fixed effect of hotels to adjust the potential bias brought by the primary model. In addition, we propose two efficient instrumental variables: the distance from the hotel to the airport and the distance from the hotel to the high-speed railway station. Prior researchers have found that distance to public transportation is a significant determinant of location satisfaction and, to a certain extent, affects the online rating (Yang et al., 2018). However, we use the test of overidentifying restrictions in Stata to check the exogeneity of the instruments. The result cannot reject the

original hypothesis that the instrumental variables are effective ( $p\text{-value}>10\%$ ). Further, our rank-sum tests corroborate the above arguments. The result shows no significant difference in customer satisfaction between hotels close to the airport ( $\text{Prob}>|z|=0.2741$ ) or railway station ( $\text{Prob}>|z|=0.6224$ ) and other hotels. This result finely confirms the validity of instrumental variables. The coefficients of the research variable in Table 6 are all positive and significant, Thus, confirm our findings above.

Table 6: Robustness check of the baseline model.

	Dependent variable: Overall_Rating		
	(1) ologit	robustness check	
		2sls	meologit
Trans_Amenity_Variety	0.023*** (7.15)	0.020*** (6.14)	0.026** (2.13)
Other Controls	Yes	Yes	Yes
Hotel Grade	Yes	Yes	Yes
Travel Type	Yes	Yes	Yes
User Grade	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	187,447	187,447	187,447
R-squared		0.053	
Number of groups			201

Notes: 1. We report z-statistics in parentheses. 2. \*\*\*  $p<0.01$ , \*\*  $p<0.05$ , \*  $p<0.1$ . 3. Due to page limits, the estimates of some variables are not reported.

### ADDITIONAL ANALYSIS

#### Zero-price Effect

Shampanier, Mazar, and Ariely (2007) defined the zero-price effect. The zero-price effect means that a free product is attractive enough for users to give up another preferred alternative product because zero price conveys the idea of no cost and increases perceived value. The hotel provides complimentary amenities so that customers can enjoy differentiated services while avoiding external expenses. Some complimentary amenities have proven to improve the perceived value (Nicolau & Sellers, 2012; Palmeira, 2011; Papiés, Eggers, & Wlömert, 2011). Perceived value is also recognized as an essential factor to impact customer satisfaction (El-Adly, 2019; Hu, Kandampully, & Juwaheer, 2009; Kuo, Wu, & Deng, 2009). Therefore, we posited that complimentary transport amenities occupy a dominant position in promoting satisfaction. We use Dominance Analysis to compare the contribution of free transport amenities and non-free transport amenities to customer satisfaction. The result in Table 7 shows that the variety of free transport amenities completely dominates the variety of non-free transport amenities.

Table 7: General dominance statistics: ordered logistic regression.

Number of obs=187447 Overall Fit Statistic=0.0320		
All Subsets Fit Statistic=0.0317		
Overall_rating Dominance statistic Ranking		
Charge_Trans_Variety_Amenity	0.0001	2
Free_Trans_Variety_Amenity	0.0003	1

#### Asymmetric Relationship: the Adoption of the Three-factor Theory

The three-factor theory reveals an asymmetric relationship between hotel attributes and customer satisfaction. It divides hotel attributes into three categories: basic factors, performance factors, excitement factors. Basic factors mean that the lack of them will cause customer dissatisfaction, but their presence will not bring customer satisfaction. Performance factors mean that the lack of them will cause customer dissatisfaction, and the provision will bring customer satisfaction. Excitement factors mean that the lack of them will not depress customers, and the provision will get customers satisfied. We adopt the penalty-reward contrast analysis (PRCA) in this study to explore which category the transport amenity should belong to. The model is as

follows: We create a dummy variable, *Trans\_Variety\_Low*, to recode the hotel without any transport amenities. Then, we create another dummy variable, *Trans\_Variety\_High*, to recode the hotel that provides all transport amenities. We use the order logistics regression and the same set of covariates as the previous model in this additional analysis. Column (1) in Table 8 indicates that, in general, the transport amenity is a performance factor. To explore the effect of travelers' profiles on this asymmetric relationship, we use grouped regression model. Column (2)-(3) in Table 8 report that the transport amenity is an excitement factor for leisure travelers and a basic factor for business travelers.

Table 8: Applying three-factor theory to define the transport amenity.

	(4)	Grouped regression	
		Leisure travelers	Business travelers
Trans_Variety_Low	-0.135*** (-5.70)	-0.111*** (-3.97)	-0.214*** (-4.64)
Trans_Variety_High	0.125** (2.10)	0.142** (2.00)	0.145 (1.15)
Other Controls	Yes	Yes	Yes
Hotel Grade	Yes	Yes	Yes
Travel Type	Yes	Yes	No
User Grade	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	187,447	117,887	69,560

Notes: 1. We report z-statistics in parentheses. 2. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. 3. Due to page limits, the estimates of some variables are not reported.

## DISCUSSIONS, IMPLICATIONS, AND LIMITATIONS

### Discussion of Findings

The present research seeks to advance our understanding of strategies to improve the convenience of a hotel by proposing and testing a model that explores the impact of transport amenities on customer satisfaction. We focus on customers' peripheral route to process the post-purchase experience based on the elaboration likelihood model. Quantity is widely regarded as a peripheral cue to process information. In this study, we choose a variety of transport amenities as a peripheral route to evaluate the hotel's performance. We validate the proposed models by using a dataset assembled from a famous online travel community. The empirical results of this study lead to some interesting findings that previous studies have not revealed.

First, the findings show that the variety of transport amenities has a positive impact on customer satisfaction. The results also indicate that the effect exists in both hotels with low and high transport convenience. The findings thus underscore that, besides the central route, such as service quality, customers will also use the peripheral route to evaluate the experience. As expected, compared with leisure travelers, business travelers emphasize the variety of transport amenities in a hotel and put more weight on them when rating. As we stated above, business travelers prefer more convenient hotels. Another potential explanation is that business travelers usually use a peripheral route to process information because of busy schedules.

In addition, we do some additional analysis. The results indicate that complimentary transport amenities dominate the contribution to customer satisfaction. The potential explanation is that complimentary services make customers more tolerant when evaluating the experience. We also adopt the three-factor theory to define transport amenities. We illustrate that the transport amenity is a basic factor for business travelers and an excitement factor for leisure travelers.

### Theoretical Implications

The current research makes critical theoretical contributions to the existing elaboration likelihood model literature. First, to our knowledge, this is the first study to focus exclusively on post-purchase information processing in the hospitality industry based on ELM. Though regarding service quality as an antecedent of customer satisfaction has reached a consensus, some peripheral cues such as variety have not been investigated. We advance the knowledge base by focusing on transport services to explore how the variety of transport amenities, a peripheral cue, affect customer satisfaction. This study provides valuable knowledge for our understanding of post-purchase information processing. Although some bias may exist in measuring some variables, this provides some ideas for researchers and practitioners. That is, not only what customers have experienced but also what they have seen determines their satisfaction.

Secondly, we enhance the existing hotel location literature. The existing hotel location research focuses primarily on identifying fixed location factors associated with higher occupancy rates and customer satisfaction. Few studies thus far have examined the flexible factors relating to alleviating hotel location disadvantages. As such, the present research seeks to advance our understanding of strategies to improve the convenience of a hotel by exploring the efficient leverage of the

transport amenity. The empirical results show comprehensive guidance for hoteliers about when and how to use transport amenities and the target of transport amenity.

### Managerial Implications

Our research may eventually help hoteliers recognize that perceived variety will significantly positively impact service evaluation. In order to strengthen customers' perceived variety, hotels can mount some guide signs in the hotel lobby or elevators. This study also helps hoteliers address the practical needs of a hotel manager to balance cost and benefit for arranging services. Our results empirically suggest that hoteliers can selectively offer transport amenities according to hotels' themes. For hotels that mainly serve business travelers, offering various transport amenities seems a necessary expense. However, for hotels that mainly serve leisure travelers, it can depend on the situation. Besides, according to the zero-price effect, hotels can select some amenities to offer free of charge regularly.

### Limitations and Future Research

Several limitations of the study warrant careful consideration. First, we only used the number of transport amenities shown on the hotel reservation page to measure the variety of transport amenities which may bring some potential bias. Future research could overcome this issue by mining from customers' online review text to measure perceived quality and variety more precisely. Second, our research focuses on observed customer satisfaction and the variety, thus limiting our ability to investigate the psychological processes underlying the behavior, which may weaken the theoretical contributions of this study. As such, further questionnaire research or laboratory studies are required to provide additional insight into the underpinning mechanism of our findings. Moreover, the data used in this research was collected from a Chinese online travel community. The majority of its visitors are Chinese. Considering that some cognition differences can be found among different national cultures, future research can conduct similar studies in the international online travel community such as TripAdvisor or Yelp.

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## The Impact of Digital Marketing and Customization on Service Innovation: Case of Moroccan Healthcare Services Companies during COVID-19

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### ABSTRACT

COVID-19 outbreak has affected the customers' preferences and purchasing patterns as a result of the restrictive regulations taken by governments. Thus, service companies must adapt to this change by focusing on innovation as a solution to survive this crisis. Therefore, the basic objective of this study is the development of an integrated framework to investigate the impact of digital marketing and customization on service innovation in the context of the COVID-19 crisis. Data were collected from 53 Moroccan companies operating in the healthcare services industry. The data was analyzed, and the theoretical model was validated using Partial least square (PLS) and structural equation model (SEM). The findings show that: integration of digital marketing improves service innovation; customization of service offerings improves service innovation; customization has a higher impact on service innovation compared to digital marketing; and finally, customization has a significant effect on digital marketing. The contribution of this study is to emphasize the roles of customization and digital marketing, during the COVID-19 crisis, on companies' service innovation so that they can differentiate their offered services and survive the current crisis.

*Keywords:* service innovation, digital marketing, customization, global health crisis, COVID-19.

### INTRODUCTION

The increased digital development of new technologies has introduced new business opportunities (Huang, 2011) and pushed service providers to focus more on service innovation (Domazet & Neogradi, 2019; Tether, 2005). According to Dereli (2015), innovation is considered as the most valuable, and companies that can develop new ways and bring new products or services to the market are the most successful. Therefore, companies have become more service-oriented, and service innovation has gained an increased focus in academic research (Dotzel, Shankar, & Berry, 2013; Ordanini & Parasuraman, 2011).

However, the concept of service innovation is still novel (Flikkema et al., 2019), and its theories need to be further explored (Ostrom et al., 2010). The literature review of service innovation research revealed that digital marketing and certain fields of research in marketing literature such as customization are relevant to service innovation (Bright & Daugherty, 2012; Engelstätter & Sarbu, 2010; Jin, He, & Song, 2012; Kasiri et al., 2017; Wu, 2014). Therefore, for this study, we chose to focus on digital marketing and customization as literature shows that a restricted number of studies deal with the way that they both impact independently service innovation (Tether, 2005; Toivonen & Tuominen, 2009; Gallouj, 2002; Domazet & Neogradi 2019; Maglio & Spohrer 2008; Wu, 2014). This study will investigate the main research question: Is there any relationship between customization, digital marketing, and service innovation?

### THEORETICAL BACKGROUND, MODEL, AND HYPOTHESIS:

This study reviewed the literature regarding service innovation and digital marketing in companies (Aas & Pedersen, 2010; Cheng, Shiu & Dawson, 2014; Kiang, Raghu & Shang, 2000; Nawaz & Kaldeen, 2020; Putri & Fithrah, 2017; Storey et al., 2016; Wu, 2014), in order to identify determinant variables to form a theoretical model.

Authors differ in the literature regarding the definition of service innovation and how it is used (Coombs & Miles, 2000; Witell et al., 2016). Building on a Schumpeterian approach, Toivonen and Tuominen (2009) defined service innovation as "a new service or such a renewal of an existing service which is put into practice and which provides benefit to the organization that has developed it; the benefit usually derives from the added value that the renewal provides the customers." Literature on new service development (NSD) commonly views service innovation as a process and often uses the terms NSD and service innovation interchangeably (Menor, Tatikonda & Sampson, 2002).

In literature, strategic innovation management (Lee & Grewal, 2004) and Digital marketing (Bright & Daugherty, 2012) are the most relevant bodies of literature to service innovation research. Furthermore, certain fields of research in the Marketing literature, such as research into customization, are also relevant to service innovation (Engelstätter & Sarbu, 2010; Jin et al., 2012; Kasiri et al., 2017; Wu, 2014). Accordingly, Wu (2014) and Bitner and Brown (2006) argue that researchers need to contribute to inter-disciplinary research on services, as service innovation is liable to be the outcome of a number of components, contextual aspects, actors, and interactions (Toivonen & Tuominen, 2009).

#### **Service innovation items:**

##### ***Technology leadership and Service leadership:***

According to Wu (2014), leadership consists of two research constructs in service innovation: Technology leadership and service leadership. These two factors are considered the main dimensions of the strategic response to service innovation (Ha, Janda, & Muthaly, 2010; Lee & Grewal, 2004).

##### ***Business and Market Opportunity Analysis:***

Song and Parry (1997) assume that the ability to identify the business and market opportunity is important to the service provider. Thus, Crawford and Di Benedetto (2000) argue that providing the most desired differentiating characteristics in services requires testing and refining concepts developed earlier in the process with key customers and users based on their feedback. They also assume that an effective business analysis will assist the service provider to select the best service(s) to develop based on analysis of market potential, customer preferences, and advantage relative to competing services (Crawford & Di Benedetto, 2000).

##### ***Marketing innovation:***

Defined by Aas and Pedersen (2010) as:

- Changes to product design of goods or services
- Changes to the packaging of goods
- New media or techniques for product promotion
- New marketing strategy
- New methods for product placement or sales channels
- New methods of pricing goods or services

##### ***Service innovativeness:***

It is defined as the degree of newness/originality/radicalness of the service offering (Chen, Damanpour, & Reilly, 2010; Evanschitzky et al., 2012; Storey et al., 2016), and considered a key success factor likely to differentiate a new service from its competing offerings (Cheng et al., 2014; Agarwal, Erramilli, & Dev, 2003; Ettlie & Kubarek, 2008). Service innovativeness is also included the new features introduced to the market by the offered service and its unconventional way of solving problems (Cheng et al., 2014).

#### **Digital Marketing:**

##### ***Concept of Digital Marketing:***

Trainor et al. (2011) see digital marketing as a form of innovation that will promote customer satisfaction and retention. Frost and Strauss (2016) gave a simpler definition by referring to digital marketing as the result of information technology applied to traditional marketing.

According to Techopedia (2015), digital marketing includes a set of internet marketing techniques with key objectives of developing visibility and generating sales by enabling customers to interact with products and services of the business through digital media promotion. Furthermore, Cintra (2010) underlines that digital marketing is a strong tool for competitive companies since creative and up-to-date advertisements lead to consumer attractiveness and interest in researching the company's services and products. Similarly, Jung, Perez-Mira, and Wiley-Patton (2009) noted that the changes in technology and consumer behavior have always been the main drivers of change in marketing strategies.

#### **Digital marketing items:**

##### ***Social media:***

It is defined as the online communication and interaction between people on certain media platforms (Frost & Strauss, 2016). The variables of social media marketing in this study are described using several indicators mentioned in the study of Nawaz and Kaldeen (2020) and Putri and Fithrah (2017). These variables include:

- Relationship: Forming a relationship with customers through existing media.
- Communication: The interaction between sellers and consumers/buyers.
- Post-Purchase Interactions: Communication between the seller and the buyer following a concluded sale transaction
- Information Format: The delivery of complete and clear information to capture the consumers' attention.

**Customer engagement:**

Customer engagement is a psychological process and mechanism that builds customer loyalty to the brand (Muchardie, Yudiana & Gunawan, 2016). Moreover, it can be determined using several indicators such as the wealth, clarity of explaining information about the goods and services offered, a clear multimedia content to attract the interest of consumers, a high level of interactivity that can lead to greater online participation, a correct description of the product/service offered, the information presented in an entertaining way that will capture more positive attention and a novelty of content that will further stimulate customer interest.

**Purchase intention:**

According to Mirabi, Akbariyeh, and Tahmasebifard (2015), purchase intention is similar to decision making, whereby consumers determine their likelihood, willingness, or plan to purchase certain brands. It can be identified by several indicators (Nawaz & Kaldeen, 2020; Putri & Fithrah, 2017). First, a transactional indicator is related to the tendency of a person to buy the item or service offered. Second, a refractive indicator is related to the tendency of a person to refer products or services to others—third preferential indicator is related to an interest that defines preference between choosing another product or service. And fourth, an exploratory indicator related to an interest that defines the conduct of an interested person to seek information about the product or service of interest.

Many scholars mentioned the impact of technology and digital development on service innovation (Tether, 2005; Toivonen & Tuominen, 2009; Gallouj, 2002; Domazet & Neogradi, 2019). Researchers argued that new technology is an essential part of innovation in service systems (Maglio and Spohrer 2008) and consider it the main driver of service innovation (Tether, 2005; Toivonen & Tuominen, 2009; Wu, 2014). Moreover, Calle et al. (2020) emphasize the role of advanced technologies when combined with the use of digital capabilities for internet-based marketing on servitization. Therefore:

*H1: Digital Marketing has a significant positive impact on service innovation.*

**Customization:**

Customization is the strategy that enables customers to adjust products and services according to their preferences (Gilmore & Pine, 1997). Researchers argue that integrating customization and standardization of offered services is necessary to improve service quality (Kasiri et al., 2017), and the consumers' perceived customization is likely to impact service diversity to enhance consumer's needs (Wu, 2014), which in turn will enhance the company's offered services. Therefore:

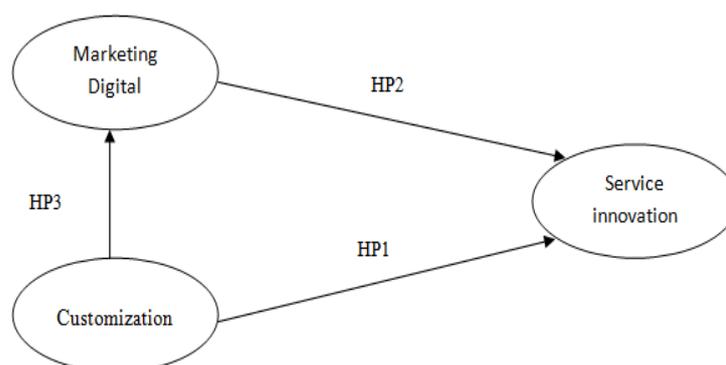
*H2: Customization has a significant positive impact on service innovation.*

COVID-19 crisis resulted in fundamental changes in customers' preferences, purchasing patterns (Lewis, 2020; Wang et al., 2020), and their purchasing behavior (Zaoui et al., 2021). Consequently, customers will seek new customized products or services to satisfy their needs, which in turn push firms to navigate new opportunities to survive under the ongoing crisis (Li-Ying & Nell; 2020). Thus, with customized products or services, the companies will face the challenge of promoting. COVID-19 crisis has raised the interest in digital marketing for firms to reach customers (Alshaketheep et al., 2020) and increased the development of new technologies and online shopping popularity (Popcorn, 1992; Zalega, 2018). Kiang et al. (2000) have stated that product customization is one of the factors leading to market the products or services on the Internet and most successful online marketing companies belong to companies that provide digital or high customization potential products or services. Therefore, in this study, we will investigate if there is a significant relationship between customizing services and advertising via digital marketing in COVID-19 crises.

*H3: Customization has a significant positive impact on digital marketing.*

**A model to link digital marketing, customization, and service innovation:****Theoretical model:**

Our model is developed based on field research and an integration of the scholarly literature regarding service innovation and digital marketing (Wu, 2014; Aas & Pedersen, 2010; Song and Parry, 1997, 2009; Storey et al. 2016; Cheng et al., 2014; Nawaz & Kaldeen, 2020; Putri & Fithrah, 2017; Kiang et al., 2000).



Source: The authors

Figure 1: Theoretical model linking digital link marketing, customization, and service innovation.

### METHODOLOGY AND SAMPLING:

The analytical studies on service innovation and digital marketing developed in the previous studies mentioned above do not provide an exhaustive view of the impact of both digital marketing and customization on service innovation and a potential relationship between customization and digital marketing.

Quantitative analysis using an empirical study was adopted to test the theoretical model in figure 1 and to verify the hypotheses presented above. Moreover, COVID-19 was used as a case study. Data for this study was collected by developing a structured questionnaire based on previous studies and conducting a survey. The questionnaire deployed structured questions to help respondents evaluate their companies' digital marketing and customization along with their perceived opinion about service innovation. Moreover, a parallel translation method was used (Kalay & Lynn, 2015; Zaoui et al., 2021) to translate some questionnaires to French (second language in Morocco), to avoid language barriers and make it easier for respondents who did not speak English. Three experts working in the field of healthcare services in two companies revised our questionnaire and solved any difficulty in understanding the questions. Furthermore, a pilot study was not conducted since the items for the measurement were derived from previous studies. (Nybak & Jenssen, 2012).

The scales for the variable were derived using items based on the compilation of different studies (Table 1). The measurement of the dependent variable, service innovation, consists of items combined and developed based on the literature review from the studies of Aas and Pedersen (2010), Song and Parry (1997, 2009), Storey et al. (2016), Cheng et al. (2014) and Wu (2014). Measurement items of customization come from the study of Wu (2014). Moreover, digital marketing was measured by items from the study of Nawaz and Kaldeen (2020) and Putri and Fithrah (2017).

This empirical study was conducted on Moroccan medical healthcare services companies. The medical healthcare services sector was chosen because of the increased number of companies offering customized healthcare services in Morocco during the COVID-19 crisis. These companies provide customized services such as assisting with home medical consultation and analysis, affording specialist doctors for emergent home checkups, ensuring emergent medical transport, and installing and monitoring medical equipment and materials at home. Consequently, this sector has the potential of benefitting from the emerging digitalization as well as the new opportunities resulting from the current COVID-19 crisis.

Sample selection was carried out using a database of 86 medical healthcare service companies in the region of Grand Casablanca in Morocco. We drew a sample of 60 companies using systematic random sampling. Moreover, to adhere to safety regulations during this pandemic, we contacted each company by phone or email to explain the study's purpose and to request participation in our study. Questionnaires were sent by email in order to adhere to safety regulations during this pandemic. The research was conducted in compliance with certain ethical responsibilities, such as respecting respondents' choices of not responding to questionnaires and protecting their anonymity. We requested two answers from each company to avoid single-source bias (Kalay & Lynn, 2015; Zaoui et al., 2021). Therefore, the analysis included a total of 53 companies who agreed to send back two answers to the questionnaire as required. The participants were asked to state their perceived opinions about service innovation, customization, and digital marketing of their companies in comparison to their competitors in the market. Constructs were measured using items on a 7-point Likert type scale ranging from 0 to 7 (0 = strongly disagree, 7 = strongly agree) (Table 1).

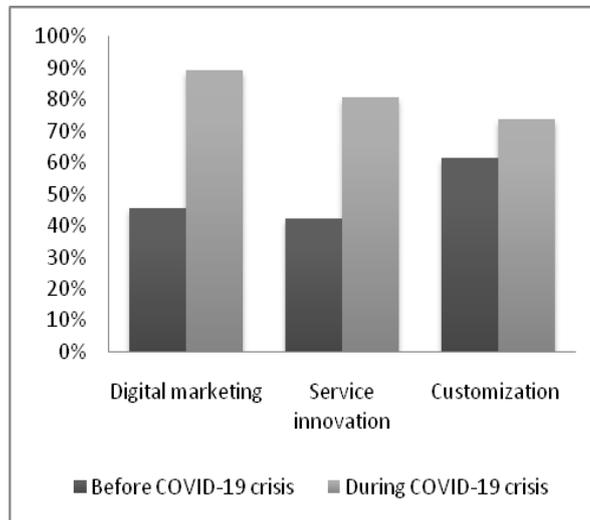
Table 1: Items measures: Mean, standard deviation, and Standardized loadings.

Constructs and scale items	Mean	Sd	Standardized loadings
<b>Service innovation (Aas &amp; Pedersen, 2010; Song &amp; Parry, 1997, 2009; Storey et al., 2016; Wu, 2014)</b>			
Technology leadership (TL)	3,774	1,712	0.81
Business and Market Opportunity Analysis (BMO)	3,038	1,414	0.70
Marketing innovation (MI)	3,792	1,606	0.85
Service innovativeness (SI)	3,170	1,476	0.72
Service leadership (SL)	4,057	1,522	0.76
<b>Customization (Wu 2014)</b>			
Your company provide more options for the customer to meet their needs (MO)	4,717	1,571	0.90
Your company allow customers to choose different services (SD)	4,396	1,652	0.86
Your company give customers greater control over customizing service (GC)	4,811	1,770	0.88
<b>Digital marketing (Nawaz &amp; Kaldeen, 2020; Putri &amp; Fithrah, 2017)</b>			
Social media (SM)	4,830	1,450	0.87
Customer engagement (CE)	5,415	1,559	0.86
Purchase intention (PI)	5,038	1,715	0.86

Source: This study

**Service innovation, digital marketing, and customization during COVID-19 crisis:**

The coronavirus disease 2019 (COVID-19) pandemic has impacted healthcare services companies and institutions both in Morocco and worldwide and has forced them to make changes to how they work and adopt innovative practices. Thus, we conducted a preliminary survey with the selected 53 healthcare services Moroccan companies. Respondents from these companies were asked first whether the way they carry out service innovation, customize their services and use digital marketing to promote them has changed during the COVID-19 crisis. Most respondents indicated a strong business response to the COVID-19 crisis across those three factors (see figure 2). We found that there is an increase of 39% in the adoption of service innovation, 43% in digital marketing, and 13 % in customization during the COVID-19 crisis compared to before it. This explains that most companies consider developing and investing in digital marketing, improving and creating new services, and responding to new emerging consumer needs by customization as a response to the COVID-19 crisis.



Source: the authors

Figure 2: Customization and digital marketing influence on service innovation during the Covid-19 crisis.

**Empirical results:**

In this study, SmartPLS 3 software was used to apply the partial least square (PLS) method for the development and test of a path model to estimate the measurement and structural parameters in the structural equation model (SEM) (Chin, 1998). Moreover, the study followed Sosik, Kahai, and Piovosio (2009) suggestion to use the PLS approach due to the relatively small sample size.

We used AMOS 16 to conduct confirmatory factor analysis (CFA) to assess the validity and reliability of service innovation, customization, and digital marketing constructs (Hair et al.,1992). CFA indicates a good fit for the theoretical model (Table 2). Furthermore, the loading factors of the items were greater than 0.4 and ranged from 0.70 to 0.90 (table 1). This shows that the items are significant according to the study of Straub, Boudreau, and Gefen (2004).

The reliability test shows that the values of Cronbach’s Alpha were higher than the acceptable level of 0.70 (table 2); therefore, it meets the standards of reliability for the survey instrument (Nunnally,1978). The average variance extracted (AVE) values of constructs are greater than the minimum required criteria of 0.5 (Fornell & Larcker, 1981). In addition, evaluating the overall model fit indices indicate a good fit (CFI=0.91, GFI=0.83, and RMESA=0.06).

Table 2: Reliability test.

Constructs	Cronbach’s Alpha (α)	Average Variance Extracted (AVE)
Service Innovation	0.837	0.601
Customization	0.861	0.781
Digital Marketing	0.839	0.753

Source: This study

In addition, the highest correlation was between customization and digital marketing (0.67). Correlation between customization and service innovation ( $r=0.46$ ,  $p<0.05$ ), and digital marketing and service innovation ( $r=0.29$ ,  $p<0.05$ ) are significant and positive (figure 3).

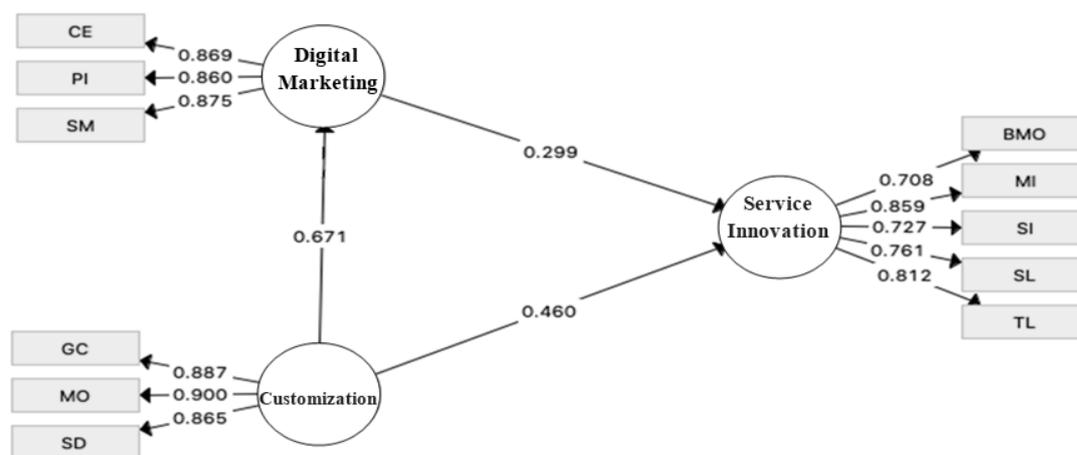
Table 3 presents the hypotheses, the analysis of the causal paths in the structural model, and t-values. The standardized loadings have significant t-values ( $p < 0.01$ ), which shows that all indicators are relevant to the constructs they specify. The three hypotheses are significant, which shows that the theoretical model is reliable and supports the three hypotheses.

Table 3: Empirical results.

Hypotheses	Hypothesized links	Standardized estimate	t-values	Significance
H1	Customization → Digital Marketing	0.67	8,14	Sig
H2	Customization → Service Innovation	0.46	9,17	Sig
H3	Digital Marketing → Service Innovation	0.29	2,01	Sig

**Sig = Significant, NSig = Not significant, t values all significant at  $p < .05$ .**

Source: This study



Source: This study

Figure 3: Relationship paths.

### DISCUSSION:

This study’s objective is to test the influence of customization and digital marketing on service innovation, along with the influence of customization on digital marketing during the COVID-19 crisis. The three hypotheses showing the impacts were significantly supported based on data collected from 53 medical healthcare Moroccan companies.

Results showed that customization of services impacts service innovation. In other words, companies who integrate consumers’ perceived customization in their offered services have higher indicators of innovation services. These companies tend to diversify their services and enhance their quality to meet the consumer’s needs (Kasiri et al.,2017), especially during the COVID-19 crisis where service needs become more specific and require customization.

This study also confirmed that digital marketing impacts service innovation. As new technologies become widespread, reaching more customers through digital platforms becomes easier. Moreover, the current COVID-19 crisis has made customers dependent on digital platforms for purchasing more than ever before. Therefore, medical healthcare services started creating and offering new services to reach more customers and specifically online customers. In particular, this research emphasizes the role of digital marketing as a competitive advantage for service providers during this COVID-19 crisis. This finding is consistent with Tether (2005), Toivonen and Tuominen (2009), and Domazet and Neogradi (2019).

Lastly, results supported that customization has a significant relationship with digital marketing. In other words, customized services and integration of new emerging customer’s needs during the COVID-19 crisis influences the medical healthcare companies marketing choices and pushes them to focus more on digital marketing opportunities to survive the ongoing crisis. This result is consistent with studies of Li-Ying and Nell (2020) and Kiang et al. (2000). Thus, Moroccan medical healthcare service companies need to increase the use of online platforms to meet the changes in their customers’ preferences and add value to customer service.

### IMPLICATIONS:

This study shows that companies can successfully overcome this health crisis by improving their service innovation. This can be done if companies focus on innovating on their services along with considering the key factors of customization and digital marketing.

The results of this study can be applied in the Moroccan context to help medical healthcare services companies gain a competitive advantage as creative service providers during the COVID-19 crisis. First, managers of healthcare services companies must focus on customization to increase their service innovation. For this, these companies must provide more options for the customer to meet their needs, allow them to choose different services, and give them greater control over customizing their chosen service. When Moroccan healthcare services companies interact more with their customers, it will likely impact their service innovation as they will tackle new opportunities for new possible services. Second, Moroccan healthcare services companies must focus more on digital marketing and developing e-commerce platforms during the COVID-19 crisis in order to cope with the customer's new purchasing behavior, due to which they can provide innovative services to increase their customer loyalty and survive the crisis.

### CONCLUSION:

The research objective of this study is to empirically test the factors impacting service innovation among Moroccan healthcare services companies during the COVID-19 crisis. The data was collected from 53 companies, and the results showed that customization along with digital marketing has a significant and positive relationship with service innovation. This study also emphasized the high impact of customization on the digital marketing of healthcare services companies.

This study has a few limitations that give new recommendations to future scholars. First, this study was conducted with a limited sample size of healthcare services companies. Therefore, future researchers can focus on increasing the sample and consider other industries to generalize their findings. Second, the sample used in this study was taken from companies located in Morocco. Thus, the findings are limited and cannot be generalized to other countries. Future studies can be extended to various industries and samples to explore more generalized results. Third, the analysis did not include any mediator, so future scholars can include more factors in the given model to explore and test more associations. Lastly, this study is not longitudinal, and it did not fully test the causal characteristics of the relationships; therefore, future scholars should consider a longitudinal design to investigate the causal relationships of the constructs.

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## The Impact of Platform Social Responsibility on Consumer Trust

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### ABSTRACT

The concept of social responsibility has been widely applied incorporates business philosophy to gain the trust of consumers. With the rise of two-side platforms, platforms have popped up the limelight along with the hot topic of the "sharing economy." Despite this, we do not know much about the underlying mechanisms of consumer trust. A questionnaire survey was conducted with 263 consumers from China to explore the consequences of platform social responsibility on consumer trust. The results demonstrate that the implementation of social responsibility by platforms significantly increases consumer trust. Additionally, consumer confusion plays a mediating effect, and platform network externality plays a moderating role. Briefly, the platform does not play a dominant role in regulating supply and demand as we might think since the consciousness of consumer groups is rising. Their autonomy to collect information and make decisions after perception cannot be ignored. The study shows that sharing economy platforms should take their social responsibilities into consideration, rather than taking them as a subsidiary role. Platforms should see consumer trust as a key end rather than a means to promote profits.

*Keywords:* Platform social responsibility, consumer trust, consumer confusion, perceived risk, network externalities, WOM substantiveness.

### INTRODUCTION

In recent years, more platforms have emerged that work to integrate supply and demand and address the waste of resources. The sharing economy encompasses the concept of underutilized resources (Cheng, 2016). These platforms present people with a more socially responsible image. But Murillo *et al.* (2017) raise serious questions as to whether the positive social and environmental claims of shared platforms should be taken for granted in general. Evidence from the Chinese consumer market shows that some platforms have been plagued by controversy over driver qualification issues and the illegal collection of personal information. Online ride-hailing platforms are facing a huge crisis of trust. Furthermore, trust is a fundamental element in the sharing economy (Möhlmann, 2015). The fulfillment of social responsibility by these platforms is likely to be an objective result rather than a subjective goal. Parguel *et al.* (2011) proposed that platform operators will deliberately create a good profile of social responsibility which have social and ecological value. Yet the business model of the platform is indeed for profit. These specious images can provoke great confusion in consumers who make decisions. We took a cue from the theoretical conception provided by Tzeng and Shiu (2020), who investigated the impact of consumer confusion on trust. Our contribution is that although various studies on sharing platforms are underway, many of them have been conducted from a psychological perspective. Considering the platform attributes, network externality is added as moderating variable. Besides, such a study is rare.

All in all, this article revolves around the relation between platform social responsibility and consumer trust. Our research focuses on the following question: How does consumer perception of platform social responsibility erode consumer trust through the path of consumer confusion in the context of the sharing economy? We extend the gap between consumer confusion and trust under platform features. The following aspects will be explored in this paper next, which are literature review, model construction and hypothesis, research methodology, research discussion, and research conclusion.

### LITERATURE REVIEW

#### Platform Social Responsibility

The current research on social responsibility is focused on the topic of enterprises. In contrast, there are very few studies on platform social responsibility. Internet platforms have their own property, so the role of platform social responsibility is more prominent in the security and privacy dimension. Sharing platforms have a long history of influencing consumer cognition with a positive image. Thus people expect more from them. Previous scholars have focused more on the impact of different dimensions of CSR on the purchase decisions of consumers, as shown in Table 1 (Shao *et al.*, 2020; Gao *et al.*, 2017). Consumer trust is a mediator variable.

Table 1: Overview of research related to corporate social responsibility.

Author (Published time)	Research topic	Research method	Conclusion
Yuan Tian, Chiako Hung, Peter Frumkin (2020)	An empirical study about the impact of cross-sector corporate social responsibility on purchasing high-tech products.	Adopt a between-subject lab experiment to investigate the effects.	Companies can generate trust by fulfilling their social responsibility. In the field of CSR, the mediating role of consumer trust is validated.
Alice Mazzucchelli, Martina Gurioli <i>et al.</i> (2021)	Key factors for a successful food sharing platform: CSR, APP familiarity, and community social support.	Multiple regression and FsQCA.	The article attempts to shed light that CSR awareness enhances consumer behavioral responses. CSR combined with social support produces a positive response to the food platform.

### Consumer Trust

Existing research findings have focused on the effect of consumer trust on consumer buying behavior. It has been demonstrated that network externalities have a positive relationship with consumer trust. It can be concluded that network externalities are a key factor in the generation of consumer trust.

Table 2: Overview of research related to consumer trust.

Author (Published time)	Research topic	Research method	Conclusion
Z Shao, Y Guo, X Li, SJ Barnes (2020)	Study on the joint influence of ex-ante factors on willingness to sustain trust.	Use the structural equation modeling technique.	Disposition to trust is positively correlated with trust while moderating the influence of structural assurance on trust.
S Gao, J Jing, H Guo (2017)	Factors influencing consumer trust in car-sharing service platforms.	Conduct empirical research.	Increased consumer familiarity with the platform will increase trust, and consumers trust the platform before focusing on word-of-mouth.
Jung J, Park E, Moon J, Lee WS (2021)	Based on TAM extended features, this paper explores the accountability of shared accommodation platform services.	Questionnaire survey.	Network externalities have a positive impact on both trust and interaction. Besides, as the size of the network grows, individuals will allow consumers to trust the platform more.

### The Association of Platform Social Responsibility and Consumer Trust

The finding that the fulfillment of social responsibility by platforms has an impact on consumer trust is widely confirmed by previous studies. In the context of the sharing economy, riding-hailing platforms are seen as new models with core competence (e.g., improved resource utilization and increased employment). In practice, these insights are not the only conclusions. For example, Airbnb claims that they are more environmentally friendly than staying in hotels (Parguel *et al.*, 2017), which is, in fact, very difficult to assess. The wild boom of DiDi is not due to consumer acceptance of its business model but to capital expansion. While it has increased employment opportunities, they have boosted the risk of crime occurring because of poorly qualified drivers. Companies may go about creating a good image of social responsibility for the sake of reputation, and this self-reported image is disconnected from actual behavior. Based on such facts, consumers can be confused about the social responsibility shown by the platform, further affecting consumer trust.

Nevertheless, the existing studies suffer from the following two shortcomings. The first is that most studies define the strengths and weaknesses of platform social responsibility and then examine how to increase trust or repair it. The second is that most of the attention is focused on corporate social responsibility. There are still relatively few studies on platforms. We will fill in the gaps above. The hypothesis in this paper arises from the fact that platforms have ambiguous images of social responsibility that are often difficult for consumers to discern. This can lead to consumer confusion while drawing on existing research where network externality moderates consumer confusion and trust.

### Related Theories

#### Network externality

Lots of scholars indicate that two-sided markets refer to the existence of two or more different user groups in a market and the existence of cross-network externalities among each other. That is, the scale of user participation on one side will affect the motivation of the other user to access the platform. (Armstrong, 2006; Chen, 2016; Jullien, 2005; Du *et al.*, 2019) That is, the utility of the platform is determined by both supply and demand. Because the platform has such property, the value it creates

for individual users increases with the total amount of users (Cennamo & Santalo, 2013; Edelman, 2015; Zhu & Iansiti, 2012). However, the nature of platforms leads to an asymmetry of user information. Especially, Vieira *et al.* (2018) investigate the acceptance of shared platforms by evaluating how perceived network externality moderate the adoption of Uber. Thus network externality is an important factor in building consumer cognition and trust in the two-sided platform.

### Consumer confusion

In China, the largest retail e-commerce market, consumers struggle with a confusing, low-trust environment (Tzeng and Shiu, 2020). The Internet has increased the availability of information, and in the face of massive amounts of information, consumers can perceive information overload that exceeds the load. Businesses are constantly developing new products to attract consumers' attention and achieve the purpose of occupying the market. This gives rise to the similarity and ambiguity of products or services. Walsh *et al.* (2007) proposed that the above three dimensions reduce user loyalty. A study by Shiu (2021) showed that consumer perception of confusion usually results in a pair of opposite outcomes. The first one is to stop continuing the purchase and gather more information to help in decision making. The second is to tolerate this present and rely on their consumer inertia to make decisions. This high uncertainty of the outcome will have a complex impact on consumer trust.

### MODEL

It builds on the original literature and draws on some research on CSR. We believe that platform social responsibility has its own qualities and is a relatively new concept. With the background of new issues arising in practice, we construct the relationship as shown in Figure 1. Next, we present the hypothesis.

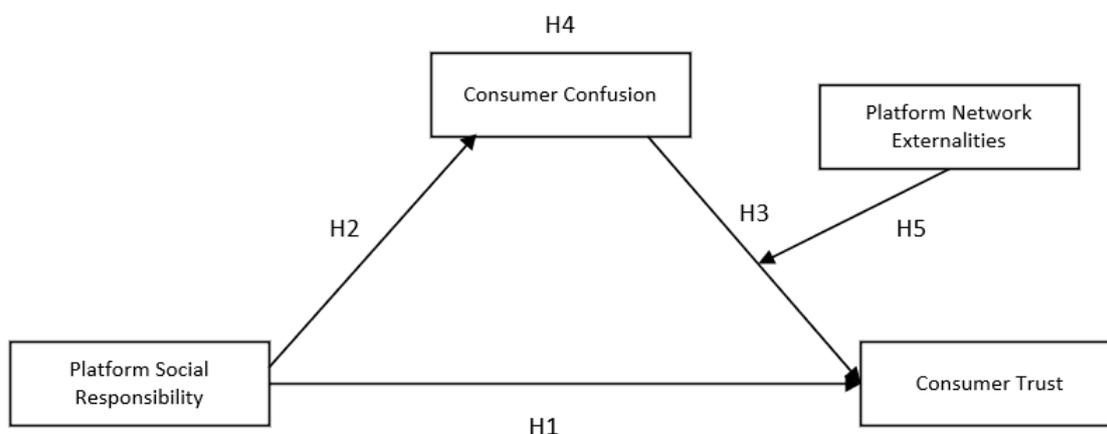


Figure 1: Research Framework.

### Research Hypotheses

**H1: Platform social responsibility is positively associated with consumer trust.**

**H2: The impact of platform social responsibility will be negative on consumer confusion.**

Some platform social responsibility programs deliberately present a good image to consumers, and consumers perceive an overabundance of positive information. They do not think deeply and judge the authenticity of the information, so consumer confusion is reduced.

**H3: Consumer confusion is negatively related to consumer trust.**

Consumer communication to share CSR information and knowledge positively affects consumer trust (Kim, 2019). Conversely, due to the lack of consumers' knowledge about the meaning of platform social responsibility and other reasons, they will be confused about the scope, authenticity, and usefulness of platform social responsibility fulfillment and have vague perceptions about the benefits of platform social responsibility fulfillment to themselves and the society and economy, etc., such as the lack of or even deviation from the perception that platform shared services can reduce the environmental burden, which in turn weakens consumers' trust in the platform. To sum up, consumers' confusion about the social responsibility of platforms can reduce consumer trust.

**H4: Consumer Confusion is a moderated effect on platform social responsibility and consumer trust.**

Previous studies have focused on the following two topics: corporate social responsibility increases consumer trust, which is a strong causal relationship. The other is trust remediation through socially responsible behavior shaping a good corporate image. The Internet allows consumers to know more about the market, with a more ambiguous image of the platform and a more similar image of different platforms, which can generate consumer confusion. This has a negative effect on consumer trust.

**H5: The moderating role of network externality in mediating the role of consumer confusion on consumer trust.**

A high level of network externalities causes users to perceive that more people are using the platform, and the more users join, the more useful each person perceives it to be. At the same time, this gives each user a hint that more and more people are concentrating on the platform. This phenomenon shapes the platform's good reputation and wide recognition, which in turn increases consumer trust.

**METHODOLOGY**

In order to quantitatively study the above relationship between platform social responsibility and consumer trust, this study designed a questionnaire as follows with reference to previous classical scales on related variables. The questionnaire was developed from a consumer perspective, with platform social responsibility as the independent variable, consumer trust in the platform as the dependent variable, and consumer confusion in the process as the mediating variable, cross-network externalities as the moderating variable, and the questions involved in the questionnaire revolved around consumers' feelings and experiences related to using the taxi-hailing platform.

**Measurement**

Referring to previous scales with good validity and applicability, such as consumer trust and confusion, and adapting them appropriately to the specific situation of this study, specific scales were designed and will be presented in the appendix.

**Empirical Analysis****Sample selection and data collection**

The questionnaire was distributed to 263 consumers who have experience in using the taxi platform, of which 263 questionnaires were validly returned, and the descriptive statistics about the questionnaire data are shown in the following table.

Table 3: Statistics report: background check.

Characteristics	Types of sample	Numbers of sample	Percentage
Gender	Male	109	41.44
	Female	154	58.56
Education	Junior high school	11	4.18
	High school	10	3.80
	Technical school	25	9.51
	College	49	18.63
	Undergraduate college	155	58.94
	Master's degree and above	13	4.94
Age	18 years old and below	6	2.28
	18-25 years old	102	38.78
	26-30 years old	37	14.07
	31-40 years old	48	18.25
	41-50 years old	58	22.05
	50 years old and above	12	4.56
Frequently used ride-hailing platforms	Didi Riding-hailing	190	51.35
	T3 riding-hailing	37	10.00
	Flower Piggy Taxi	32	8.65
	First appointment car	3	0.81
	Mei tuan Taxi	42	11.35
	others	66	17.84

As can be seen from Table 3, the ratio of men to women in the sample is about 4:6, and its equilibrium is acceptable to the extent that it does not affect the study, while undergraduates account for a vast majority of them, and the age is more concentrated between 18-50 years old, with the youngest group aged 18-25 years old. In addition, among the frequently used taxi platforms, thanks to the advantage in market share, Drip riding-hailing occupies half of the sample, while other riding-hailing platforms such as T3 riding-hailing and Flower Piggy riding-hailing have a small share of frequent use.

**Reliability and validity analysis**

For the quantitative data, Cronbach's alpha coefficient was used to measure the reliability of the sample responses, with higher values of the coefficient indicating better reliability. Exploratory factor analysis was also used to measure the consistency of the factor and question design, and the data are summarized below:

Table 4: Reliability and validity analysis.

variable	Research dimension	Number of items	Cronbach $\alpha$	KMO	Bartley number
Platform Social Responsibility	Environmental Responsibility	5	0.947	0.944	3624.578
	Ethical Responsibility	5	0.942		
	Economic Responsibility	3	0.895		
Consumer Confusion	Similarity Confusion	3	0.880	0.945	3038.362
	Overload confusion	4	0.891		
	Ambiguity confusion	7	0.930		
Network Externalities	Perceived network size	3	0.902	0.923	1586.031
	Perceived external credibility	3	0.880		
	Perceived complementarity	2	0.757		
Consumer Trust	Brand Competence Trust	4	0.907	0.927	1219.867
	Brand goodwill trust	2	0.823		

As can be seen from Table 4, the Cronbach alpha coefficient values of the correlation dimensions of all four variables in this study are greater than 0.75, which indicates that the questionnaire has a good question design rationality and can support further research analysis. Regarding the structural validity test of the questionnaire, the results were found to be significant using Bart's spherical test for all variables, and the KMO values were greater than 0.9, and the cumulative variance explained after rotation was greater than 70%, indicating that the questionnaire items allow the data information to be extracted effectively. Exploratory factor analysis of the sample data, combined with factor loading coefficients greater than 0.5, can confirm that the factors correspond well to the study items, and the question items correspond to the expected dimensions, thus synthetically indicating that the study data have a good level of structural validity. In addition, since this questionnaire was designed with reference to the results of existing studies, the content reliability of the question items can be guaranteed.

**Intermediary effect analysis**

In order to verify whether the hypothesis of Consumer Confusion as a mediating variable in the theoretical model is valid, the Bootstrap method was used to conduct a mediating effect test to analyze the mediating effect of consumer confusion in the relationship between the influence of platform social responsibility and consumer trust, and the specific test results are as follows:

Table 5: Results of intermediary effect analysis.

variable	CT					CC					CT				
	B	Standard deviation	t	p	$\beta$	B	Standard deviation	t	p	$\beta$	B	Standard deviation	t	p	$\beta$
Constant	1.462**	0.168	8.688	0.000	-	3.754**	0.198	18.931	0.000	-	2.875**	0.233	12.348	0.000	-
PSR	0.597**	0.042	14.385	0.000	0.665	-0.401**	0.049	-8.199	0.000	-0.453	0.446**	0.042	10.674	0.000	0.497
CC											-0.376**	0.047	-7.976	0.000	-0.371
R <sup>2</sup>	0.442					0.205					0.552				
Adjust R <sup>2</sup>	0.440					0.202					0.548				
F	F(1, 261)=206.931, p=0.000					F(1, 261)=67.220, p=0.000					F(2, 260)=160.103, p=0.000				
c (Total effect)	a	b	a*b (Intermediary effect value)			a*b (95% BootCI)			c' (Direct effect)		Effect ratio				
0.597**	-0.401**	-0.376**	0.151			0.090 ~ 0.272			0.446**		25.271%				

Note: \* Significant at p<0.05 level, \*\* Significant at p<0.01 level

Table 5 shows that the independent variable platform social responsibility is significantly and positively correlated with the dependent variable consumer trust ( $\beta=0.665$ ,  $p<0.01$ ), with a total effect of  $c=0.597$ , platform social responsibility is inversely correlated with the mediating variable consumer confusion ( $\beta=-0.453$ ,  $p<0.01$ ), and this study uses Bootstrap method and the 95% confidence interval obtained by repeated sampling. The 95% confidence interval of this study is not including 0, and when platform social responsibility and consumer confusion are added together in the regression equation, the direct effect is significant ( $c'=0.446$ ,  $p<0.01$ ), and the mediating effect value of the cross term are in the same direction as the direct effect. Taken together, the above analysis suggests that consumer confusion mediates and partially mediates the relationship between platform social responsibility and consumer trust influence.

### Analysis of moderating effects

In the theoretical model of this study, network externalities are used as moderating variables to regulate the relationship between consumer confusion as a mediating variable acting on consumer trust. In order to test the existence of the moderating effect and the specifics of the regulation at different levels, the moderating effect test is conducted, and the specific results are shown below:

Table 6: Results of analysis of moderation effects.

	Model 1					Model 2					Model 3				
	B	Standard deviation	t	p	$\beta$	B	Standard deviation	t	p	$\beta$	B	Standard deviation	t	p	$\beta$
Constant	1.881	0.207	9.068	0.000**	-	3.259	0.148	21.963	0.000**	-	3.178	0.153	20.801	0.000**	-
CC	-0.284	0.055	-5.173	0.000**	-0.281	0.160	0.041	3.873	0.000**	0.158	0.171	0.041	4.132	0.000**	0.169
NE						0.974	0.049	19.802	0.000**	0.900	0.972	0.049	19.856	0.000**	0.898
CC*NE											-0.060	0.030	-2.038	0.043*	-0.056
$R^2$	0.522					0.810					0.813				
Adjust $R^2$	0.518					0.808					0.810				
F	$F(2, 260)=141.823, p=0.000$					$F(3, 259)=367.478, p=0.000$					$F(4, 258)=280.001, p=0.000$				
$\Delta R^2$	0.522					0.288					0.003				
$\Delta F$	$F(2, 260)=141.823, p=0.000$					$F(1, 259)=392.111, p=0.000$					$F(1, 258)=4.152, p=0.043$				

Note: \* Significant at  $p < 0.05$  level, \*\* Significant at  $p < 0.01$  level

As can be seen from Table 6, the moderating effect test is divided into three models, and model 1 includes Consumer Confusion, model 2 adds moderating variables on this basis, model 3 adds the product term of CC and NE and centralizes CC and NE, the results show that the coefficient of the cross term of Consumer Confusion and Network Externalities is negative and significant ( $p=0.043 < 0.05$ ), implying that there is a reverse moderating effect of network externalities when consumer confusion has an impact on consumer trust, and the hypothesis of the moderating effect mentioned in the study is verified. The simple slope analysis of the moderating effect shows that the effect of consumer confusion on consumer trust is more significant at low levels of network externalities, while at high levels of network externalities, the effect of consumer confusion on consumer trust is weakened.

## DISCUSSION

Through empirical research and analysis with taxi-hailing platforms, this study verifies that consumer confusion plays a mediating role in the impact of platform social responsibility on consumer trust. Specifically, platform social responsibility has a positive impact on consumer trust, and the intrinsic mechanism of this impact is partially transmitted through consumer confusion; if consumers are confused about the perception of platform social responsibility, then the efficiency of the overall positive impact of platform social responsibility fulfillment on consumer trust will be reduced. Therefore, in order to gain more consumer trust, taxi platforms should pay attention to consumers' confusion about platform social responsibility in addition to platform social responsibility fulfillment, and clearly define which behaviors of platforms belong to the fulfillment of social responsibility and the positive impact these behaviors will have on consumers, economy, and environment so that the efficiency of platform social responsibility effect on consumer trust can be improved. In addition, this study verifies that network externalities play a reverse moderating role in the effect of consumer confusion on consumer trust, i.e., network externalities weaken the effect of consumer confusion on consumer trust. As the platform's user base increases, the perceived utility of consumers increases, which, combined with the information interaction within platform users, weakens the effect of consumer confusion on consumer trust. In other words, when the operation scale of the ride-hailing platform expands, it can gain network externalities and promote the positive impact of platform social responsibility on consumer trust, thus gaining more stable and sticky consumers and contributing to the long-term economic benefits of the platform. In addition to ride-sharing platforms, we should also consider the relationship between corporate social responsibility and consumer trust on other platforms. On the basis of literature search, the mediating variables should be enriched to explore the cause and effect of the problem more comprehensively.

The sample may be limited in representation and should be expanded in the future. Most of the samples for this study are young people aged between 18 and 25, and more than half of them have a bachelor's degree. However, the audience of the taxi platform is indeed them. It also needs to pay attention to the cognitive dissonance caused by consumers' confusion, as well as the beliefs, behaviors, and behavioral perceptions adopted by consumers. Platforms' performance of social responsibility only helps consumers to make favorable inferences about products and services provided by enterprises. The decrease in consumer trust may be due to various reasons, and further detailed division is needed. There are also some new studies focusing on the impact of platform social responsibility on consumer sentiment, which is also an important consumer response. These are all areas where our model needs to be extended in the future.

## CONCLUSIONS

This study investigates the impact of platform social responsibility on consumer trust from the perspective of platform social responsibility. Based on the theoretical foundation of previous studies, we introduce consumer confusion as a mediating

variable and network externality as a moderating variable in the research model in order to explore the mechanism of the intrinsic effect of platform social responsibility on consumer trust. In order to test the relevant hypotheses in the model, we designed a questionnaire on the impact of platform social responsibility on consumer trust by referring to the measurement questions of previous works on the variables involved in this study and making appropriate adjustments and modifications according to the specific content of this study and collected a total of 263 valid questionnaires. In conducting the data analysis, we first sorted and screened the data, and after analyzing the samples through factor analysis, mediating effect test, and moderating effect test, we concluded that consumer confusion plays a partially mediating role in the influence of platform social responsibility on consumer trust, and consumer confusion plays a reverse role in transmitting the positive influence of platform social responsibility on consumer trust, and in addition, the conclusion indicates that network externalities play a reverse moderating role in the effect of consumer confusion on consumer trust. Therefore, in practice, platforms expecting to gain more consumer trust by fulfilling social responsibility should pay attention to consumers' perceptions and definitions of platform social responsibility and dispel consumers' confusion about platform social responsibility through auxiliary means such as publicizing platform social responsibility fulfillment and publishing annual platform social responsibility reports, while seeking network externalities with platform scale operation to promote platforms to gain more consumer trust in the same social responsibility fulfillment and expand the platform's social responsibility. At the same time, the platform's scale of operation seeks network externality and promotes the platform to gain more trust from consumers and develop long-term stable users for the platform, thus realizing a virtuous cycle of social responsibility and economic benefits. Of course, there are limitations in this study. Due to various objective conditions and factors, the sample collection is not sufficient, and there are other influencing factors on the inner mechanism of platform social responsibility on consumer trust that have not been taken into account, and further research is expected to be conducted by other scholars. This paper also provides a new perspective, as more and more consumers realize that some of the platforms' socially responsible behavior may be a side effect of their realization of monopoly and resource integration, which is not as positive as expected. If the platform claims that it is actively fulfilling its social responsibility, but its words and actions are inconsistent in the process, it is highly likely to bring about an inestimable crisis of trust and an irreparable image.

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## The More Engaged, the More Generous: Examining the Influence of Viewers' Engagement on Their Gifting Behavior in Live Streaming Services

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### ABSTRACT

Social Live Streaming Services (SLSSs) is an emerging form of social media that facilitates real-time interaction between streamers and their viewers through video streaming. With its growing prevalence worldwide, a wealth of literature has investigated its unique features of IT affordances and para-social interactions between streamers and their viewers, leaving viewers' inner development and adjustment of attitudes and actions during the watching remained largely unknown. This study empirically examined the effects of viewers' previous active engagement on their subsequent purchase behavior in SLSSs from the perspective of self-perception and perceived sunk costs. Results show that both free gifts and Danmaku (i.e., real-time comments) length significantly induce the purchase of charged gifts and that there are significant gender discrepancies underlying these mental attribution processes.

*Keywords:* Social live streaming services (slsss), self-perception theory, sunk cost, danmaku, virtual gifts

### INTRODUCTION

*"It's the time that you spent on your rose that makes your rose so important."*

*THE LITTLE PRINCE*

Social Live Streaming Services (SLSSs), an increasingly prevalent means of social networking, enable users to share information through real-time video streaming. It is more than a combination of traditional social media and e-commerce because it possesses the prominent characteristics of those two platforms. First, it affords users two-way communications through its online environment, which is like the functions of traditional social media. Second, its unique gifting mechanism enables viewers to appreciate and support streamers' performance, which is similar to the service products provided in traditional e-commerce platforms. Gifting is a unique means of monetization on SLSSs first appeared in China. During a live streaming show, viewers could purchase virtual gifts through digital payments and send them to streamers. Last but not least, SLSSs facilitate a real-time interaction among all of these social and business activities, making the process of information sharing more instant and convenient. Figure 1 shows an example of SLSSs on the mobile end in China. On the top of the screen is the live video streaming with Danmaku (i.e., real-time comments) floating on it. In the lower comment area, viewers could observe others' real-time comments and virtual gifts.

China, as one of the leading counties in the field of SLSSs, has started tapping the market since 2005 with its initial goals of enhancing user stickiness to the websites. In 2020, users of SLSSs in China had reached 560 million, accounting for 62% of total internet users (Wei, 2020). In other countries, SLSSs has also attracted a huge number of users, such as Twitch, YouTube, and BIGO live. Among the five main sources of income (i.e., gifting, advertising, VIP membership fee, game promotion, and commission) in SLSSs, they are gifting accounts for 90% of the total revenue in the field of entertainment and online video games (Wei, 2020). Therefore, it is of great importance to explore factors impacting viewers' gifting behaviors in this unique cyber ecosystem.

Apart from the majority of existing literature on SLSSs that explore the roles of IT affordances in live streaming promotions, the rest focusing on the gifting behaviors have mostly interested in the relational benefit, and para-social interactions between streamers and viewers, resulting in viewers' inner development and adjustment of attitudes and actions during the watching remained largely unknown. More specifically, there is a lack of vertical investigation on the relationships between viewers' previous engagement and their subsequent behaviors (i.e., purchase virtual gifts) in SLSSs. Furthermore, empirical evidence on the influence of demographics on viewer behaviors is also sparse. Therefore, our research questions are raised accordingly to bridge these gaps.



Figure 1: An Example of SLSSs on the Mobile End in China

*Does viewers' previous active engagement (i.e., sending free gifts and Danmaku) in SLSSs have an impact on their subsequent purchase of charged gifts? If yes, is there a demographic heterogeneity (i.e., gender) in these effects?*

To deal with these questions, we first adopted the concept of cognitive consistency, the Self-Perception Theory, and the perspective of sunk costs to build up the framework for this study. Then, empirical analyses were conducted based on a real-world live streaming data set, and two robustness checks were exhibited to eliminate the endogeneity derived from reverse causality and omitted variables. Lastly, the theoretical and practical implications of the findings were demonstrated, together with the limitations of this study and further research directions.

## THEORETICAL FOUNDATION

### Self-Perception Theory

Self-perception theory, first proposed by Daryl Bem, refers to the practice that human inferences of their own perceptions could partly be influenced by their previous behavior and its potential causes (Bem, 1972). Originated from the literature of psychology, this theory provides a novel perspective for cognitive consistency, a phenomenon that individuals tend to keep their attitudes and opinions congruent in order to achieve inner harmony and balance.

A wealth of literature in social psychology has supported and developed this theory by addressing that human attitudes and emotions could be shaped by their own behaviors and actions, driven by the internal desire for cognitive consistency and congruency. For example, it is found that individuals regard themselves as more friendly to the environment if they have engaged in recycling-relevant behaviors (Chaiken & Baldwin, 1981). Likewise, it is observed that frequent volunteering work could lead individuals to become more considerate and kind-hearted with others (Brunelle, 2001). Woosnam *et al.* (2018) attributed such phenomenon to self-identifying stereotypes that could induce individuals to absorb and act correspondingly or oppositely.

Apart from the application in social psychology, the Self-perception theory has also been introduced to the field of Information Systems (IS) to explore how users' perceptions are shaped and adjusted by observing their own behaviors. For example, Xu *et al.* (2020) found that when facing events of infectious diseases in Social Networking Services (SNS), there are a series of reciprocal feedbacks in lieu of a one-way effect between users' attitudes toward risks and their sharing behavior at different stages. Comparable findings were revealed in research examining the impact of online reviews on customer loyalty, demonstrating that consumers with review behaviors contribute to a significantly larger volume of orders than those without (Lohse & Kemper, 2019). These findings attest notion that cognitions and perceptions follow actions and behaviors and are of great value for IS researchers to reinspect user behaviors from a dynamic and reciprocal perspective rather than a static and straightforward one.

Although the core idea of this theory seems akin to Embodied Cognition Theory, which proposes that human bodily states and behaviors could reversely affect their mental activities and subsequent actions, these two theories differ greatly in the underlying mechanisms, self-perception theory addresses the impacts of individuals' self-observation and self-reflection of their own behaviors on the subsequent perceptions, emphasizing the activeness and consciousness of introspection (Bem, 1972). In contrast, Embodied Cognition Theory posits that humans tend to reuse the neural resources derived from their previous sensory and bodily experience so that they unconsciously make similar perceptual and motoric reactions when facing the stimuli that are intrinsically related to the initial ones, which is more about a passive and unconscious reflex without awareness (Anderson, 2010; Barsalou, 2008; Krishna & Schwarz, 2014).

### **Social Live Streaming Services (SLSSs)**

Social Live Streaming Services (SLSSs), an emerging form of social networking services, have attracted an increasing number of users and researchers these years due to its unique features in real-time interactions and monetization strategies in recent five years. Researchers pointed out that maximizing personal income and capabilities, as well as the sustainability of the environment, are fundamental objectives of SLSSs (Yang & Gao, 2017). Moreover, most of the SLSSs are designed to facilitate users' usage and promote users' engagement by means of various gamification strategies such as fan badges and virtual goods (Scheibe & Zimmer, 2019). With the popularity of SLSSs, the steadily growing literature on related topics has gradually formed three main streams of research.

The first stream of research focused on the content contribution and usage motivations of different social live-streaming platforms, namely, how could streamers produce more popular content and the motivations behind their using behaviors (Bründl & Hess, 2016; Bründl *et al.*, 2017; Cai & Wohn, 2019; Zhao *et al.*, 2018; Zimmer & Scheibe, 2019). The second stream of research focused on the monetization approaches in the mode of e-commerce promotions on social live streaming platforms, in other words, how could streamers and platforms make boost sales through effective advertising in live streaming shows (Chen *et al.*, 2019; Hou *et al.*, 2020; Li & Kang, 2020; Wongkitrungrueng & Assarut, 2020; Xu *et al.*, 2019).

The third stream of research focused on another way of monetization, virtual gifts, or digital items purchases made by viewers while they are viewing the live streamings shows. Researchers have provided different theories and perspectives to understand the motivations of viewers' gifting behaviors. For example, from an identity investment perspective, viewers' consumption of charged gifts is significantly affected by their class identity, while their consumption of free gifts is motivated by their relational identity when there is a high social density in this live streaming room (Li *et al.*, 2019). Another study shows that cognitive absorption and virtual crowd experience positively influence viewers' purchase intention for virtual gifts (Guan *et al.*, 2019). Similarly, it is also found that both contextual factors (e.g., interactivity and social presence) and personal factors (e.g., trait curiosity and social media dependence) could influence viewers' consumption intention (Guo *et al.*, 2019; Li *et al.*, 2018).

### **Danmaku and Virtual Gifting in SLSSs**

Danmaku, also known as "bullet curtain," is a Japanese term that refers to a type of real-time comments displayed on the screen of the video. Originated in [Niconico](#), a video-sharing platform in Japan, Danmaku enables viewers to share comments synchronously as the video plays. More specifically, Danmaku appears in accordance with the time axis of the video, which differentiates it from traditional static comments posted below or beside the video.

In 2008, Danmaku was introduced to China as Danmu and rapidly gained popularity among young Chinese Internet users. Adopted by several major video-sharing platforms such as Bilibili, [iQiyi](#), and Tencent Video, Danmaku has become the main source of attraction for video streaming services in China. In SLSSs, it is also a key function for viewers to interact with streamers and other viewers in real-time, largely enhancing users' sense of telepresence during the watching experience.

Virtual gifts in SLSSs are intangible products that could be bought and sent to streamers by viewers, serving as real-time performance feedback and streamer-viewer relationship enhancement. According to the pricing, virtual gifts are categorized into two types: free gifts and charged gifts. Free gifts are offered by platforms freely, while charged gifts can only be obtained through digital payment.

Although both free gifts and charged gifts are viewers' expressions of liking to streamers' performance, they take on different roles in the monetization process from the perspective of streamers and platforms. Charged gifts are the direct way for streamers and platforms to monetize their performance and services. In most cases, streamers and platforms share the earnings based on a certain ratio, so that streamers' income level largely depends on the amounts of charged gifts they receive. Although advertisements are also a way to earn money, these opportunities are scarce and mostly offered for top streamers.

Free gifts, unlike charged gifts, do not directly relate to streamers' income but are also indispensable in the monetization process for two reasons. First, they serve as a signal of the popularity of streamers as well as their performance. Since the number of free gifts is overwhelmingly beyond the charged ones, the animation and notification of sending free gifts help create an atmosphere in the virtual channel, leaving newcomers an impression that the streamer or her performance is attractive and interesting. As a result, there will be an increasing possibility for newcomers to stay longer in this channel. Second, free gifts could motivate viewers to purchase charged gifts through the shaping effect and the foot-in-the-door effect (Lammers, 1991). That is to say,

sending free gifts is a way that effectively approximates the real purchase of virtual gifts (i.e., the charged gifts) so that viewers are more likely to upgrade their consumption to charged gifts for a better experience.

## HYPOTHESIS DEVELOPMENT

### Free Gifts, Danmaku Length, and Charged gifts

According to the Self-perception theory, individuals have a tendency for introspection on their previous behaviors and make self-judgment for their attitudes accordingly (Bem, 1972). Apart from the influence mechanism of self-identifying and self-stereotyping proposed in the existing literature, the influence of sunk cost remained unexamined. Rational individuals are inclined to weigh their costs and returns in order to avoid risks and losses, and thus they would only proceed with the work that is worthy and promising. However, when their inputs sometimes could not meet comparable rewarding, some individuals might be forced by the averseness and fear of losses to continue until achieving expected outcomes (Samuelson & Zeckhauser, 1988; Simon, 2013, pp. 72-73). More importantly, with the preference for maintaining an intrapersonal cognitive consistency, their perceptions towards the work would change correspondingly to justify their previous engagements, and the subsequent behaviors could be induced from these adjusted attitudes (Bhattacharjee, 2001).

In the context of SLSSs, free gifts and the Danmaku function offered by platforms create opportunities for viewers to input their efforts. First, both interactions induce viewers to devote mechanic costs during the watching. Sending free gifts requires viewers to click the mouse on the PC end or tap the screen on the mobile phone end multiple times, while sending Danmaku requires viewers to type through keyboards or screens. Hence, viewers are encouraged to be bodily active during the watching rather than merely looking at the video. Second, beyond the mechanic cost, sending Danmaku calls for two additional costs: cognition cost and emotion cost. Organizing and structuring a sentence to express opinions and affections involves the collaborations and elaborations of certain brain regions and multiple hormones (Planton et al., 2017; Van Wingen et al., 2011). Hence, when viewers observe and reflect on these efforts they made in a channel, they are inclined to infer themselves as interested and appreciated with the performance, and thus would be more willing to pay for shows. Therefore, it is reasonable to hypothesize that sending more free gifts and longer Danmaku could induce an increase in the amount of charged gifts.

*H1: There is a positive correlation between the number of free gifts and the amount of charged gifts.*

*H2: There is a positive correlation between the length of Danmaku and the amount of charged gifts.*

### Moderating Role of Viewer Gender

Gender differences are ubiquitous across disciplines. In the field of consumer behavior, evidence shows that females and males differ a lot in buying motivations and shopping preferences (Ulbrich et al., 2011). For example, females' online consumptions are more emotional-and social-oriented while males' are more pragmatic- and functional-oriented in buying (Dittmar et al., 2004). Apart from the gender discrepancies in consumer behavior, females and males also behave dissimilarly in terms of sunk costs. Johnson and Whisman (2013) found that females are more inclined to reflect and anxious about their past decisions, actions, and experiences than males. Moreover, such a tendency of rumination and self-reflection results in the continuance of investment in previous unsuccessful events (Bruine de Bruin et al., 2014). The comparable finding reveals that compared to males, females suffer from significantly higher switching costs during the migration from the present management system to another one (Dang et al., 2015).

However, an overlooked point in this literature is that the sunk cost could be impacted by the individual's subjective sensation of the cost. More specifically, individuals might perceive the different extents of sunk cost hinging on their motivations, preferences, capabilities, and even habits. For example, individuals talented in sports would perceive finishing a marathon as less costly than those without the talent. Hence, in the context of SLSSs, viewers' perceived sunk costs of sending free gifts and Danmaku should be not only determined by their inherent sensibility and tolerance to the sunk cost but also by their inner attitudes and feelings on these actions. For example, males will perceive the less sunk cost of sending free gifts than females because they inherently prefer free gifts to charged ones in light of their functional-orientated consumption perceptions. Given that males are less sensitive to the sunk cost, it is reasonable to expect that they negatively moderate the effects of sending free gifts on the amount of charged gifts.

*H3: Compared to female viewers, the impact of the number of free gifts on the amount of charged gifts will be smaller for male viewers.*

Nonetheless, the situation becomes complicated for the Danmaku sending. On the one hand, males are less sensitive to the sunk cost than females, indicating that the main effect will be smaller for them. On the other hand, males tend to perceive more sunk costs of cognition and emotion for sending Danmaku because they are less emotionally expressive than females (Kring & Gordon, 1998). Therefore, two contradicted hypotheses are proposed.

*H4a: Compared to female viewers, the impact of the Danmaku Length on the amount of charged gifts will be smaller for male viewers.*

*H4b: Compared to female viewers, the impact of the Danmaku Length on the amount of charged gifts will be greater for male viewers.*

## METHODOLOGY

To test the hypotheses, a real-world dataset was crawled from a top E-sports streamer's channel on a leading live streaming platform in China. The data collection started on April 3, 2021, and ended on April 30, 2021, with a duration of 4 weeks. During this period, viewers (N = 121,544) that have sent at least one Danmaku in the first week were selected for the subsequent observation. That is to say. This dataset could be regarded as week-level panel data with a time length of 4. Therefore, the data size is 486,176 (121,544 \* 4).

The variables comprise three segments: viewers' demographic information, viewers' gift-sending, and Damaku-sending behaviors, and the shows' performance information. The first segment includes a viewer's gender, fan level, and noble level. Fan level is calculated by the platform in accordance with the number and monetary value of gifts a viewer sent to a streamer, reflecting the viewer's attitude and loyalty to a specific streamer. The noble level is a VIP membership providing a combo of identity-prominent services, indicating a viewer's concern on the virtual identity on the platform. Fan level and noble level were considered as control variables because fan identity and noble identity might both contribute to the charged-gifts sending behavior (Li *et al.*, 2019). The second segment reflects a viewer's activities information in a channel, including the number of free gifts, the amount of charged gifts, and the average length of Danmakus that have been sent out. The last segment consists of three different sentimental expressions in the Danmaku, indicating viewers' general impression and attitude toward the shows they watch. These three were also considered as control variables because the quality of performance could directly influence viewers' willingness to purchase the charged gifts.

Table 1: Variable Description

	Variable	Alias in Model	Description
DV	Amount	<i>lnamt</i>	The total amount of charged gifts a viewer purchased and sent during a certain period
IV	Free Count	<i>lnfreecnt</i>	The total number of free gifts a viewer sent during a certain period
	Danmaku Length	<i>lnmmlen</i>	The average length of Damaku (aka Danmu) a viewer sent during a certain period
	Gender/Male	<i>gender</i>	Set to one when the viewer is male
Controls	Fan Level	<i>lnfan</i>	A fan membership is determined by the number and the amount of gifts a viewer sent to a specific streamer, set to zero if the viewer did not send any gifts
	Noble Level	<i>lnnoble</i>	A VIP membership purchased by a viewer on a specific platform, set to zero if the viewer did not make the purchase
	Awesome Performance	<i>lnawesome</i>	The average frequency of Danmaku with the positive word in the live shows during a certain period
	Confusing Performance	<i>lnconfuse</i>	The average frequency of Danmaku with the confusing word in the live shows during a certain period
	Negative Performance	<i>lnnegative</i>	The average frequency of Danmaku with the negative word in the live shows during a certain period

To eliminate the skewness and large differences in variable scales, we log-transformed all the continuous variables to  $\ln(x + 1)$ . A two-way fixed-effects Model was adopted, and the model specification shows as follows:

$$\lnamt_{it} = \beta_0 + \beta_1 \lnfrecnt_{it} + \beta_2 \ln dmlen_{it} + \beta_3 \lnfrecnt_{it} * gender_i + \beta_4 \ln dmlen_{it} * gender_i + \gamma individual_i + \theta week_t + \delta controls_{it} + \varepsilon_{it} \quad (1)$$

### ANALYTICAL RESULTS

Table 2 presents the descriptive statistics of variables grouped by gender. The ratio between female (gender = 0) and male (gender = 1) viewers approximate 1:2 (N = 45,186 vs. N = 76,358) because the channel we observed focus on E-sports performance and female fans are generally fewer than male fans. It could also be found that the mean length of Danmaku sent by females is higher than those of males, with 1.496 vs. 1.132 and 3.300 vs. 3.130, respectively. In contrast, the count of free gifts sent by females is lower than that of males (31.96 vs. 47.71) while the amount of charged gifts sent by females are higher than that of males (10.54 vs. 9.611), indicating that females are more willing to spent money to express their appreciations while males are more inclined to show their support through costless means. This discrepancy is aligned with the findings that testosterone induces less generosity and more selfish decision makings especially for distant others (Ou *et al.*, 2021).

Table 2: Descriptive Statistics by Gender

VARIABLES	gender 0				gender 1			
	(1) N	(2) mean	(4) min	(5) max	(6) N	(7) mean	(9) min	(10) max
code	180,744	62,891	4	125,262	305,432	62,496	1	125,261
week	180,744	2.500	1	4	305,432	2.500	1	4
danmu_count	180,744	1.496	0	470.9	305,432	1.132	0	389.3
danmu_length	180,744	3.300	0	97.10	305,432	3.130	0	154.4
free_count	180,744	31.96	0	2,261	305,432	47.71	0	3,303
total_amount	180,744	10.54	0	95,132	305,432	9.611	0	51,510
awesome	180,744	12,165	0	51,605	305,432	12,896	0	51,605
confusing	180,744	2,676	0	7,182	305,432	2,847	0	7,182
negative	180,744	391.8	0	1,236	305,432	431.4	0	1,236
fanslevel	180,744	2.929	0	32	305,432	4.745	0	30
noblelevel	180,744	0.0331	0	6	305,432	0.0749	0	5

Table 3 summarizes variables through the lens of time. It shows that viewers' activeness in Danmaku sending and gift sending flopped sharply in the second week and then slightly fluctuated in the following three weeks. Since the observation is concentrated on the same group of people throughout the data collection window, it could be inferred that viewers' enthusiasm on the live streaming shows did not follow a steadily increasing pattern but an unstable varying pattern.

Table 3: Descriptive Statistics by Week

VARIABLES	(1) week 1		(3) week 2		(5) week 3		(7) week 4	
	N	mean	N	mean	N	mean	N	mean
code	121,544	62,643	121,544	62,643	121,544	62,643	121,544	62,643
danmu_count	121,544	2.584	121,544	0.727	121,544	0.921	121,544	0.837
danmu_length	121,544	6.717	121,544	1.894	121,544	2.128	121,544	2.034
gender	121,544	0.628	121,544	0.628	121,544	0.628	121,544	0.628
free_count	121,544	46.97	121,544	41.05	121,544	42.31	121,544	37.07
total_amount	121,544	14.39	121,544	4.105	121,544	12.32	121,544	9.013
awesome	121,544	25,058	121,544	8,278	121,544	10,685	121,544	6,476
confusing	121,544	5,019	121,544	1,741	121,544	2,201	121,544	2,172
negative	121,544	735.0	121,544	388.5	121,544	288.8	121,544	254.5
fanslevel	121,544	4.005	121,544	4.048	121,544	4.086	121,544	4.142
noblelevel	121,544	0.0589	121,544	0.0592	121,544	0.0595	121,544	0.0599

Although Table 4 shows a relatively high correlation between two key independent variables (i.e., *lnfrecnt* and *ln dmlen*) and three show performance indicators (i.e., *lnawesome*, *lnconfuse*, and *lnnegative*), the Variance Inflation Factors (VIF) of *lnfrecnt* and *ln dmlen* are 4.70 and 4.21 respectively, which are less than the threshold of 5 and could be tolerated. Moreover, in the following analysis, Coarsened Exact Matching (CEM) and Instrumental Variables will be adopted to separate the influence of control variables on independent variables.

Table 4: Correlation Matrix

	lnamt	Indmlen	gender	lnfan	Innoble	lnfreecnt	lnawesome	lnconfuse	lnnegative
lnamt	1								
Indmlen	0.194***	1							
gender	0.022***	-0.015***	1						
lnfan	0.236***	0.151***	0.169***	1					
Innoble	0.138***	0.018***	0.074***	0.176***	1				
lnfreecnt	0.274***	0.294***	0.098***	0.635***	0.039***	1			
lnawesome	0.252***	0.717***	0.047***	0.364***	0.042***	0.574***	1		
lnconfuse	0.250***	0.718***	0.047***	0.363***	0.042***	0.573***	0.998***	1	
lnnegative	0.244***	0.711***	0.049***	0.365***	0.043***	0.574***	0.987***	0.991***	1

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 5 presents the preliminary results of OLS regressions. In Model 1, only control variables were taken into consideration, and the results reveal that noble level and awesome performance are positively related to charged gifting while negative performance is negatively related to the charged gifting. In Model 2, *lnfreecnt* ( $\beta_1 = 0.117, p < 0.01$ ) and *Indmlen* ( $\beta_2 = 0.072, p < 0.01$ ) came in, and both of them show significant positive correlations with *lnamt*, supporting Hypothesis 1 and Hypothesis 2. *gender* was omitted in these models because of its fixed effects. Model 3 added in the interaction term of *lnfreecnt* and *gender*, revealing that compared to females, males significantly weakened the positive effect of free gifting on charged gifting ( $\beta_3 = -0.033, p < 0.01$ ). Hence, Hypothesis 3 was supported. Model 4 added in the interaction term of *Indmlen* and *gender*, showing that compared to females, males significantly strengthen the positive effect of Danmaku Length on charged gifting ( $\beta_4 = 0.011, p < 0.01$ ). Therefore, H4b was supported. Model 5 integrated all the variables, and all the effects hold still.

Table 5: Results of OLS Regressions

MODEL	(1)	(2)	(3)	(4)	(5)
VARIABLES	lnamt	lnamt	lnamt	lnamt	lnamt
lnfreecnt		0.117*** (0.002)	0.139*** (0.004)	0.117*** (0.002)	0.142*** (0.004)
Indmlen		0.072*** (0.003)	0.071*** (0.003)	0.065*** (0.003)	0.059*** (0.003)
freecnt_gen			-0.033*** (0.005)		-0.037*** (0.005)
dmlen_gen				0.011*** (0.003)	0.018*** (0.003)
lnfan	-0.075*** (0.011)	-0.080*** (0.011)	-0.080*** (0.011)	-0.080*** (0.011)	-0.080*** (0.011)
Innoble	0.540*** (0.200)	0.557*** (0.196)	0.557*** (0.196)	0.556*** (0.196)	0.555*** (0.196)
lnawesome	0.068*** (0.004)	0.052*** (0.004)	0.052*** (0.004)	0.052*** (0.004)	0.052*** (0.004)
lnconfuse	-0.005 (0.006)	-0.006 (0.006)	-0.006 (0.006)	-0.006 (0.006)	-0.006 (0.006)
lnnegative	-0.067*** (0.003)	-0.071*** (0.003)	-0.071*** (0.003)	-0.071*** (0.003)	-0.071*** (0.003)
2.week	-0.094*** (0.004)	-0.071*** (0.004)	-0.072*** (0.004)	-0.071*** (0.004)	-0.071*** (0.004)
3.week	-0.012*** (0.004)	0.007 (0.005)	0.006 (0.005)	0.007 (0.005)	0.007 (0.005)
4.week	-0.054*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)	-0.030*** (0.004)
Constant	0.271*** (0.014)	0.142*** (0.014)	0.144*** (0.014)	0.141*** (0.014)	0.143*** (0.014)
Observations	486,176	486,176	486,176	486,176	486,176
R-squared	0.029	0.050	0.051	0.050	0.051
Number of codes	121,544	121,544	121,544	121,544	121,544
Code FE	YES	YES	YES	YES	YES
Week FE	YES	YES	YES	YES	YES
F test	0	0	0	0	0
r2_a	0.0286	0.0504	0.0508	0.0504	0.0509

Note: Robust standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### ROBUSTNESS CHECK

Considering some covariates that might in the meantime contribute to the independent variables and the dependent variable and contaminate the causal inferences, Coarsened Exact Matching (CEM) was adopted to approximate the premises of the control experiment, in other words, the randomization. CEM as an emerging matching technique has been widely applied across disciplines in the recent decade and is regarded as more effective and efficient in imbalance reducing and model dependence than commonly used traditional matching methods (e.g., Propensity Score Matching (PSM)) (Matthew Blackwell, 2009). Different from PSM that matches pairs with close total propensity scores, CEM stretches the matching rules according to authors' ideas by coarsening the exact matching of variables to predefined groups (e.g., match pairs in the same age group in lieu of exact birthdays) (Stefano M. Iacus *et al.*, 2012).

Table 6 presents the Multivariate L1 distance of two key independents (i.e., *Infrecnt* and *Indmlen*) before and after the matching. Multivariate L1 distance refers to the overall imbalance of variables between a certain treatment group and its control group. It could be found that the imbalance drops from .8026684 to .65123378 for *Infrecnt* and drops from .61980766 to .43094981 for *Indmlen*, indicating that the matching is well conducted. Table 7 displays the regression results before and after the matching for two key independent variables, respectively. It shows that the influence of free gifting ( $\beta = 0.038, p < 0.01$ ) and Damaku length ( $\beta = 0.185, p < 0.01$ ) on charged gifting both remain significant after the matching, ruling out the possibilities to a great extent that some common factors (e.g., the fan loyalty to streamers) lead to both independent and dependent variables.

Table 6: CEM Results for Two Treatments

Treatment Dummy Variable	Multivariate L1 distance		Matching Summary	
	Before Matching	After Matching	Number of strata	Number of matched strata
Infrecnt	0.8026684	0.65123378	14397	3615
Indmlen	0.61980766	0.43094981	14397	3183

Table 7: OLS Regressions after CEM

Treatment VARIABLES	Infrecnt		VARIABLES	Indmlen	
	Before Matching Inamt	After Matching Inamt		Before Matching Inamt	After Matching Inamt
Infrecnt	0.131*** -56.7	0.038*** -10.66	Indmlen	0.286*** -33.32	0.185*** -20.37
freecnt_gen	-0.030*** (-12.32)	-0.030*** (-7.49)	dmlen_gen	-0.007 (-0.61)	0.019* -1.72
gender	-0.002 (-0.24)	-0.005 (-0.46)	gender	-0.039*** (-2.63)	-0.027* (-1.89)
Infan	0.098*** -25.4	0.311*** -82.85	Infan	0.253*** -89.06	0.264*** -95.72
Innoble	1.058*** -59.62	1.022*** -22.5	Innoble	0.934*** -52.5	0.317*** -9.93
Inawesome	0.082*** -7.85	0.109*** -5.34	Inawesome	0.107*** -10.18	0.059*** -5.8
Inconfuse	0.098*** -3.93	0.182*** -4.54	Inconfuse	0.053** -2.08	0.055** -2.16
Innegative	0.078*** -4.77	0.173*** -6.42	Innegative	0.080*** -4.84	0.054*** -3.24
Constant	-2.085*** (-6.59)	-3.582*** (-7.19)	Constant	-2.176*** (-6.82)	-1.503*** (-4.62)
Observations	121,544	94,424	Observations	121,544	94,224
R-squared	0.15	0.087	R-squared	0.136	0.126
F test	0	0	F test	0	0
r2_a	0.15	0.0868	r2_a	0.136	0.126
F	2690	1123	F	2395	1694

Note: t-statistics in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Since a viewer's free gifting, Danmaku sending and charged gifting behaviors might happen at the same time or even reversely, to eliminate the endogeneity caused by reverse causality and other omitted variables, we utilized lagged independent variables as Instrumental Variables (IV) with Two-Stage Least Square (2SLS) method in lieu of the originated ones. Lagged free gifting

and Damaku sending were highly correlated to independent variables in the current phase because people tend to behave consistently to avoid cognitive dissonance (Festinger, 1957; Harmon-Jones & Mills, 2019), and meanwhile,, were unrelated to error terms because they were not in the same window. Moreover, since the lagged behaviors occurred one week before other variables, the reverse causality was also excluded. Table 9 displays the 2SLS regression results of *lnfreecnt* and *lnmmlen*. It could be found that in the second stage of regression, the impacts of *lnfreecnt* ( $\beta = 0.055, p < 0.01$ ) and *lnmmlen* ( $\beta = 0.286, p < 0.01$ ) remained significant, indicating that the main effects still hold with instrumental variables adjusting the original independent variables.

Table 8: Summary Results for First-stage Regressions

Variable	F(4,364620)	P-value	Under-identification test		Weak
			SW Chi-sq(1)	P-value	identification test
lnfreecnt	25131.21	0.0000	45833.91	0.0000	45832.40
lnmmlen	4598.24	0.0000	13915.20	0.0000	13914.74
freecnt	1.7e+05	0.0000	40145.16	0.0000	40143.84
dmlen_gen	24381.53	0.0000	33348.00	0.0000	33346.91

Table 9: 2SLS Regression for Two Independent Variables

MODEL	(1)
VARIABLES	lnamt
<b>lnfreecnt</b>	0.055*** (0.004)
<b>lnmmlen</b>	0.286*** (0.012)
<b>freecnt_gen</b>	-0.018*** (0.003)
<b>dmlen_gen</b>	0.017* (0.010)
<b>lnfan</b>	0.076*** (0.002)
<b>lnnoble</b>	0.584*** (0.018)
<b>lnawesome</b>	0.138*** (0.008)
<b>lnconfuse</b>	-0.082*** (0.010)
<b>lnnegative</b>	-0.107*** (0.006)
<b>2.week</b>	-0.038*** (0.003)
<b>3.week</b>	0.021*** (0.003)
<b>Constant</b>	-0.048*** (0.002)
<b>Observations</b>	364,632
<b>r2_a</b>	0.103

Note: Robust standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## DISCUSSION

This study aims to investigate whether viewers' active involvement during watching live streaming could induce their pay for the services. Free gifts and Danmaku sending as two typical types of active behaviors were examined under the framework of the Self-perception theory. Although these two behaviors seem zero-cost to most viewers and streamers, they are, to some extent, not costless at all. While viewers tend to merely be concerned about the sunk cost of money during their participation in live streaming shows, they also unconsciously weigh the sunk cost of mechanics, cognition, and emotion against their engagement. These time-consuming efforts could exert a subtle influence on their attitudes toward the shows and thus could eventually shape their perceptions of loyalty to the streamer/channel. More specifically, the more efforts they made in a channel, the more probabilities that they perceive themselves as enjoyed because rational people would generally take efforts in attractive things. Consequently, these active viewers are more inclined to pay for the performance because they regard it as worthwhile.

Furthermore, considering the diversity of viewers' profiles and structures, it is of great value to explore the heterogeneity of main effects under different viewer demographics (e.g., gender).

The results of empirical analysis attested to our hypotheses that both free gifts and Danmaku length could contribute to charged-gift sending. These findings become more convincing after the following two robustness checks (i.e., CEM and Instrumental Variables) by reducing the endogeneity caused by unbalanced samples and reverse causality. The regression results also exhibited that gender moderates these two main effects in different ways. Compared to females, males impaired the positive effect of free gifts on charged gifts but underpinned the positive effect of Danmaku length. The inconsistency between these two moderating effects attests to the previous argument that individuals' self-perception process is not only affected by their inner sensitivity to sunk costs, in other words, the extent of loss aversion, but also influenced by their subjective sensation to different types of sunk costs, namely, the perceived sunk cost. Sending free gifts merely involves the cost of mechanic work (i.e., clicking the mouse or tapping the screen), and to the best of our knowledge, there is no evidence showing gender differences in it. In this case, the perceived sunk cost for females is indifferent to that of males. Therefore, due to the fact that females are more intolerant of loss, it is reasonable that they purchase more charged gifts than males do after sending free gifts. In contrast, sending longer Danmaku calls for more elaboration in organizing sentences, involving not only the cost of mechanic work (i.e., typing with the keyboard or the touch screen) but also the cognitive and emotional attribution. Since males have been proved to be less emotionally expressive than females, it could be inferred that they generally perceive a higher sunk cost in sending Danmaku (Kring & Gordon, 1998). Therefore, males are more inclined to regard themselves as devoted to a channel after conducting such expression-relevant work and thus are more willing to make the real purchase subsequently.

### CONTRIBUTION AND LIMITATION

This research contributes to the literature on SLSSs and Self-perception theory in a meaningful way. First, while the majority of research on SLSSs gives attention to the IT affordances for advertisements and promotion activities, this research concentrated on gift sending, another crucial means of monetization, enriching the diversity of perspectives on related pieces of literature. Second, to the best of our knowledge, this is the first empirical study based on the real-world data giving insights into viewers' self-development and self-adjustment of attitudes and behaviors in SLSSs during a continuous observational window. Through examining the effects of previous engagement (i.e., sending Danmaku and free gifts) on the subsequent purchase behavior (i.e., sending charged gifts), this individual-level vertical study addresses the interactions among viewers own behaviors, following inspiring researches that these activities are not independent but have subtly correlated with each other. Last but not least, this study not only empirically supports the Self-perception theory but also theoretically enriches it by introducing the idea of perceived sunk costs and demonstrating the gender heterogeneity in the self-perception process, offering the Self-Perception Theory a novel lens for the underlying mechanism.

Apart from the theoretical contributions, the study also generates practical implications for platforms and streamers in the industry of SLSSs. First, it is of great importance to design various activities for viewers to get involved in a channel, imperceptibly increasing their sunk costs of time and effort. For example, to increase their sunk cost of mechanical effort, platforms could adopt gamification strategies to encourage users' bodily movements and gestures such as hard press, swipe, and even shake the touch screens. To increase the cognitive cost, streamers could offer simple quizzes about the show content with prizes during the live streaming to attract viewers' attention and inspire their thinking. To increase the sunk cost of emotions, except for the lottery draw from Danmaku senders, platforms/streamers could also present mini questionnaires (e.g., pop up on the side of the screen) and memes/emojis for selection during the live streaming to foster viewers to express their attitudes and feelings. Second, platforms and streamers could utilize the gender differences in certain types of activities to optimize the fan economy. More specifically, as males are less willing to pay for the shows but are more sensitive to their cognition and emotional cost, they could be intentionally guided to more expression-relevant activities. Females could be offered more free gifts to increase their activeness as well as enhance user stickiness and loyalty. Last but not least, the ideas above could be generalized and promoted to any platforms that facilitate the functions of social networking, including e-commerce services, online games, and possibly Virtual Reality (VR) as well as Augmented Reality (AR) communities in the future.

This study also has several limitations. First, due to the storage and processing limitation of the real-time live streaming data, only 4-weeks of observational data were analyzed, resulting in an uncertainty of the generalization of main effects to a larger time window (e.g., 3/6/12 months). Second, since we only collected the data in one male streamer's channel, it remains unknown that whether the viewer behaviors are homogeneous in a female streamer's channel because it has been argued that viewers tend to pay more for streamers of the opposite gender (Cho *et al.*, 2019). Third, this study overlooks the social influence from peers' active participation. More specifically, viewers are exposed to others' behaviors during the live streaming and could be stimulated to reinforce some actions (e.g., impulsive buying of charged gifts) due to the social comparison and herding effects. Therefore, future research could append these crowd-related factors to the existing model.

### CONCLUSION

This study examined the effects of viewers' previous active engagement on their subsequent purchase behavior in SLSSs from the perspective of self-perception and perceived sunk costs. Results show that both free gifts and Danmaku length significantly induce the purchase of charged gifts and that there are gender discrepancies underlying this mental attribution process. Compared to female viewers, male viewers experience a weaker effect of free gifts on charged gifts and a stronger effect of Danmaku length

on charged gifts. We propose that the self-perception process is affected by both the sensitivity to sunk costs (i.e., the extent of loss aversion) and the subjective sensation to different types of sunk costs (i.e., perceived sunk costs). Males are predicted to perceive more sunk costs in sending Danmaku because of their inner less willingness for emotional expression compared to females. This study not only enriches the literature of SLSSs but also supplements the Self-Perception Theory with a novel lens of sunk costs. It also provides platforms with applicable suggestions to increase the viewer activeness, stickiness, and, most importantly, the sales of charged gifts.

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## **Toward the Development of a Revised Technology Acceptance Model**

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### **ABSTRACT**

This study develops and proposes an extended technology adoption model based on the vast literature. The proposed revised technology adoption model is a five-layer evaluation model that can be used to determine the variables that influence individuals' and organizations' embrace of new technologies. The existing technology acceptance model (TAM) and its modifications (TAM2 and TAM3) have been applied for decades in varied disciplines, including marketing and information systems, to better predict generic human perceptions, behaviors, and attitudes toward new and existing technologies. The revised TAM is less generic and includes variables pertaining to culture-tech (indigenization) that predict user behaviors and intentions to adopt new technology. This proposed TAM offers the potential to engineer destruction in the development of culture-tech or indigenous technology by allowing local customization of technological contents and features to meet the needs of individuals and organizations, especially those in developing and emerging countries. The revised TAM, if supported empirically, will guide researchers and developers to capitalize on technology innovation rooted in users' indigenous and personal attributes and characteristics.

*Keywords:* Technology, new technology, culture-tech, developing countries, emerging countries, innovation, revised TAM.

### **INTRODUCTION**

Since the early 1990s, various innovative changes and developments in the information, communication, and mobile technology field have disrupted traditional business models in many countries, transformed consumer behaviors, and created a new segment of consumers popularly known as tech-savvy or digital natives. In consumer behaviors, the adoption, acceptance, and use of different technologies, applications, and systems in everyday life have been attributed to several factors, including the proliferation of smart and portable devices, social media, and easy, frequent access to information.

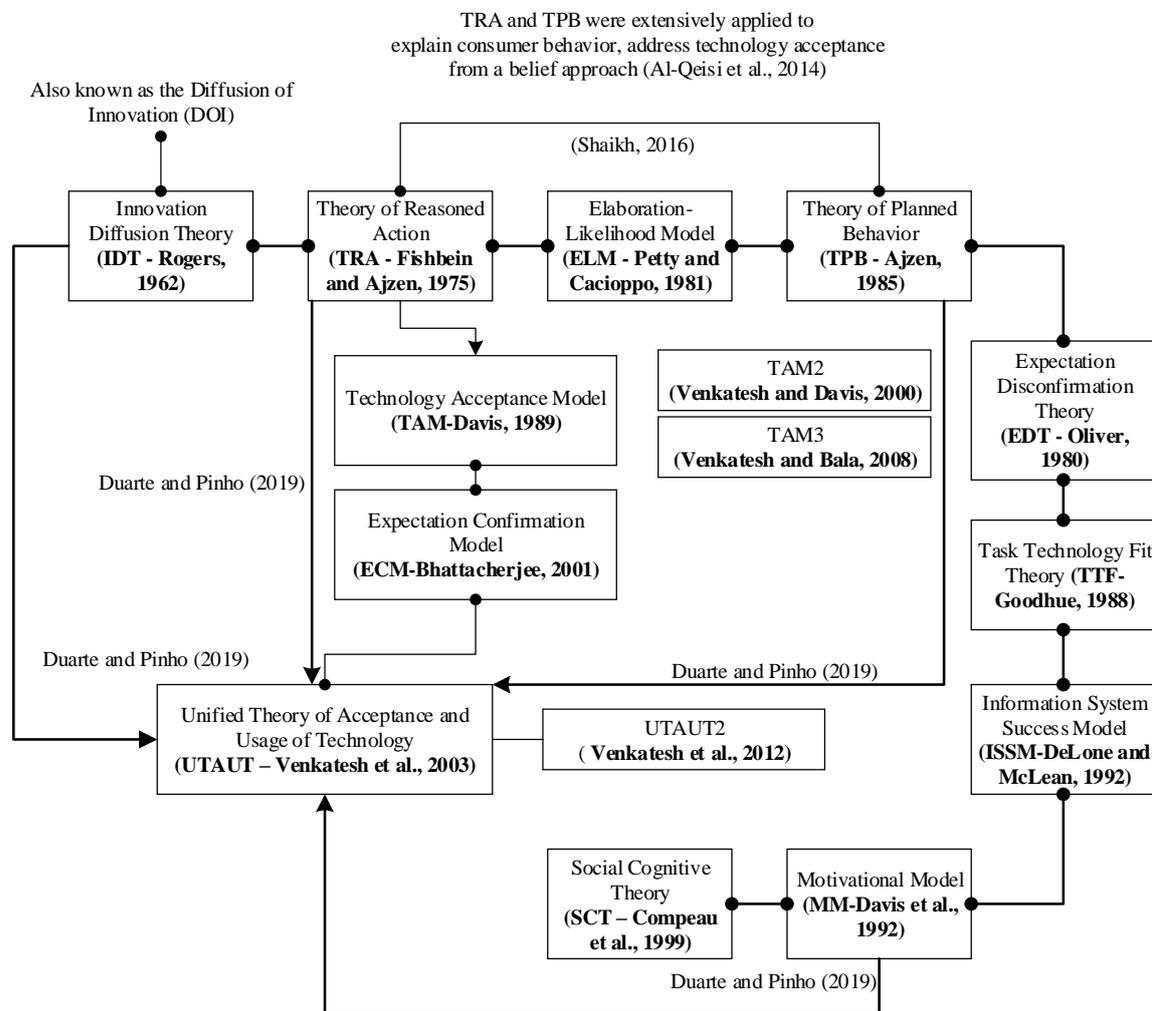
Scholars in the information systems (IS), marketing, and psychology fields have investigated the social, economic, political, and cultural factors affecting consumer adoption and usage intentions and behaviors regarding products, services, systems, and technologies in developed, developing, and emerging countries (Friederike, Maria, Andrea & Angelika, 2017; Lekhanya, 2013; Shaikh & Karjaluo, 2015). Nonetheless, successful planning, development, and deployment of technology can be difficult due to social complexity (Bradley, 2009). Overcoming these complexities requires theoretical models, theories, and frameworks to better understand the factors and the outcome variables that affect and predict human and user behaviors, attitudes, and beliefs regarding technology adoption, especially in developing and emerging countries.

The literature offers a number of models, theories, and frameworks thoughtfully designed and used by scholars to examine and understand consumer and user acceptance and usage of technology innovations and features (Lim & Ting, 2012): innovation diffusion theory (IDT; Rogers, 1962), a theory of reasonable action (TRA; Fishbein & Ajzen, 1975), elaboration-likelihood model (Cacioppo & Petty, 1981), a theory of planned behavior (TPB; Ajzen, 1991), expectation disconfirmation theory (Oliver, 1980), task technology fit theory (TTF; Goodhue, 1988), technology acceptance model (TAM; Davis, 1989; Davis, Bogozzi & Warshaw, 1989; Hu, Al-Gahtani & Hu, 2014), and unified theory of acceptance and use of technology (UTAUT; Venkatesh, Morris, Davis & Davis, 2003), among many others. TRA, originally developed and used in social psychology research (Shaikh, 2016), is largely considered to be the "mother of the theories" because it has influenced the development of other popular theories. The information-technology-specific variants of this theory include TPB, TAM, and ECM. Figure 1 depicts a summary of the theories, models, and frameworks proposed and used over the past eight decades.

The purpose of developing and proposing these models, theories, and frameworks has been to answer vital questions. How can products, services, and ideas gain momentum and diffuse through specific populations and social systems over time (Shaikh, 2016)? Why do people accept or reject IS (Szajna, 1996)? How do the TAM and TPB constructs explain the adoption of technology and services in developing countries (Glavee-Geo, Shaikh & Karjaluo, 2017)?

For years, academic scholars have applied these theories to describe and explain acceptance and continuous usage of technology from both consumer and organization perspectives (Glavee-Geo et al., 2017; Lai, 2017; Lee, Kozar & Larsen, 2003; Lim & Ting, 2012; Rose & Straub, 1998). Such use has made these theories, models, and frameworks important components, especially in the IS and marketing disciplines. For example, TAM, developed in 1989, has been widely deployed and cited, with its limitations

noted (Bradley, 2009; Jokonya, 2017; Lee et al., 2003; Surendran, 2012; Lippert & Volkmar, 2007). The revised TAM2 eliminates some of these limitations. Introduced by Venkatesh and Davis (2000), TAM2 addresses pre-and post-implementation beliefs and behaviors separately and is generally considered to be more concise and easier to understand and use (Szajna, 1996). Despite these improvements, these models in practice miss some aspects of social reality. For example, first, the adoption of technology depends on individual behaviors, which define individual interests, feelings, and thoughts (Bradley, 2009). Second, facilitating and administering innovative technology within local contexts in emerging and developing countries remains challenging (Dahlman, 2007). Third, a brief review conducted by the authors suggests that these models cannot capture or represent the cultures and social aspects of consumers and users.



Source: the study.

Figure 1: Snapshot of theories, models, and frameworks proposed and used over the last eight decades.

Given these limitations, it is believed that the cultural factors influencing users must be captured and represented in a revised adoption model to consider all individual interests in different societal contexts such as developing and emerging countries. Such consideration allows the development of a reflective system based on individual preferences and social and cultural values. After an in-depth analysis of the contemporary and past literature on technology adoption theories, models, and frameworks, this paper presents a novel revised TAM to capture and present technology to individuals and to understand the social and cultural factors that affect technology adoption. This study identifies the gaps in these models, theories, and frameworks and proposes the revised TAM as an ideal model for achieving culture-tech initiatives in emerging and developing countries.

Culture-tech initiatives aim to decolonize technology systems and their contents and features to meet the needs and expectations of common users in emerging and developing countries. Cultures shape individual perceptions, behaviors, and attitudes toward the usage of any form of technology. Technology adoption, therefore, must capture and represent the influencing cultural factors to consider all individual interests. Technology is used and applied in an environment controlled by cultural, social, economic, and political factors.

This study involved a literature review in facilitating an in-depth analysis of the different technology adoption models, theories, and frameworks used to predict technology acceptance and usage in the recent past. The literature review targeted papers on theories, models, and frameworks used to predict and understand factors and issues affecting technology adoption globally. The

keywords used to search for and identify relevant literature in both vertical (ScienceDirect) and horizontal (Google Scholar) search engines included “theories + adoption + technology,” “models, frameworks, adoption, technology,” and “technology acceptance model” in addition to other related terms. In total, 55 articles were found. After the initial screening and consideration of the purpose and scope of this study, 46 articles were shortlisted and included in this review. To interpret the data effectively, two authors were involved in coding the selected literature.

The following sections discuss the literature, research methodology, and revised TAM, including its applications. The final section presents the study’s implications, limitations, and suggested future research directions.

## **TECHNOLOGY ACCEPTANCE AND USAGE MODELS AND THEIR MODIFICATIONS**

### **Theory of Reasonable Action and Theory of Planned Behavior**

TRA, introduced by Fishbein and Ajzen (1975), is among the most widely used theories to determine individual motivational factors, behavioral intentions, and attitudes toward actual behaviors (Bradley, 2009; Lai, 2017; Taherdoost, 2018). Both TRA and TPB (Ajzen, 1991) were initially developed and used in social psychology research (Shaikh, 2016). Lai (2017) defined consumer attitudes as emotive reactions to behaviors based on belief systems and argued that personal attitudes toward technology are affected by perceptions, and attitudes are influenced by belief systems that define behaviors (Lai, 2017). Individual and collective cultures shape the four cardinal pillars of individual relationships to technology: perceptions, attitudes, belief systems, and behaviors. The first three pillars affect actual behaviors. However, prior research has proposed that current technology platforms such as electronic learning lack cultural attributes that significantly influence user perceptions, attitudes, beliefs, and actual behaviors (Joshua, Nehemiah & Ernest, 2015).

In contrast, TPB determines factors that influence behavioral intentions motivating individual attitudes toward actual behaviors (Lai, 2017). Another factor in TPB is perceived behavioral control, or the definition of actual behaviors by individual perceptions (Lai, 2017). In general, TPB addresses situations in which individuals have no personal behavioral control (Bradley, 2009). Individual behavioral intentions are functions of user attitudes, perceived behavioral control, and subjective norms, while behaviors determine actual usage.

### **Technology Acceptance Model and Its Modifications (TAM, TAM2, and TAM3)**

TRA, introduced by Davis (1989) with the underlying purpose to model technology use in the workplace (Al-Qeisi, Dennis, Alamanos & Jayawardhena, 2014). However, it is widely believed that the motivation and theoretical grounding for TAM came from TRA; in other words, the fundamental ideas for developing TAM were consistent with TRA, which holds that attitudes and intentions determine beliefs. TAM was specifically developed to predict end users’ computer and IS adoption behaviors and posits that individual behavioral intentions to adopt IS are determined by two beliefs: perceived usefulness and perceived ease of use (Shaikh, 2016). Later, Venkatesh et al. (2003) developed UTAUT with two variables: performance expectancy and effort expectancy. Performance expectancy is considered to be similar to the antecedent perceived usefulness in TAM and effort expectancy to the antecedent perceived ease of use. Venkatesh and Davis (2000) developed the modified TAM2 almost a decade later, while Venkatesh and Bala (2008) introduced TAM3 in 2008.

Initially, TAM was developed to explain computer usage behaviors (Lai, 2017). TAM was aimed at determining factors associated with technology adoption and user behaviors across different populations of technology users (Lai, 2017). Perceived usefulness focuses on users’ views of the potential of new technological platforms to advance their activities, while perceived ease of use refers to the extent that potential users expect systems to be user-friendly and effortless to use (Lai, 2017; Lim & Ting, 2012). In this study, perceived usefulness is believed to be a determining factor of technology usefulness, while perceived ease of use determines perceptions of technology as effortless and user friendly.

TAM2 assesses the mental readiness of users and the consequences of using systems to carry out tasks that define customer perceptions of usefulness. Findings have shown that TAM2 is suitable for mandatory and voluntary environments (Lai, 2017), and it has been tested in different technology contexts such as internet banking (Chan, 2004). In 2008, Venkatesh and Bala (2008) developed the technology acceptance model TAM3, which has four aspects that determine perceived usefulness and perceived ease of use: system characteristics, individual differences, facilitating conditions, and social influences (Lai, 2017).

### **Task-Technology Fit Theory**

Goodhue (1988) developed TTF with a focus on individual impacts (Lai, 2017). Put merely, TTF measures the fit between a task and technology. TTF was initially developed to evaluate workplace technology and IS adoption and its impacts on user performance (Shaikh, 2016). Instead of the antecedent fit, antecedent compatibility has been used extensively in recent research (Lai, 2017).

TTF describes technology that perfectly fits individual tasks. The model is aimed at improving and advancing adoption possibilities and increasing performance levels because technology meets user needs (Lai, 2017). TTF is used to investigate existing technology performance measures, marketplace support, and individual tasks. Its primary focus is to increase the efficiency, effectiveness, and quality of technology at meeting user needs.

Since its formulation, many scholars have applied TTF in different disciplines. For example, D’Ambra, Wilson, and Akter (2013) used it to describe, understand, and evaluate the academic use of e-books. Tripathi and Jigeesh (2015) used TTF and other theories to evaluate cloud computing adoption in multinational IT companies. However, TTF theorists and other scholars applying it have failed to describe and capture user cultures, beliefs, and other social attributes (Tripathi & Jigeesh, 2015).

**Unified Theory of Acceptance and Use of Technology and Its Modifications**

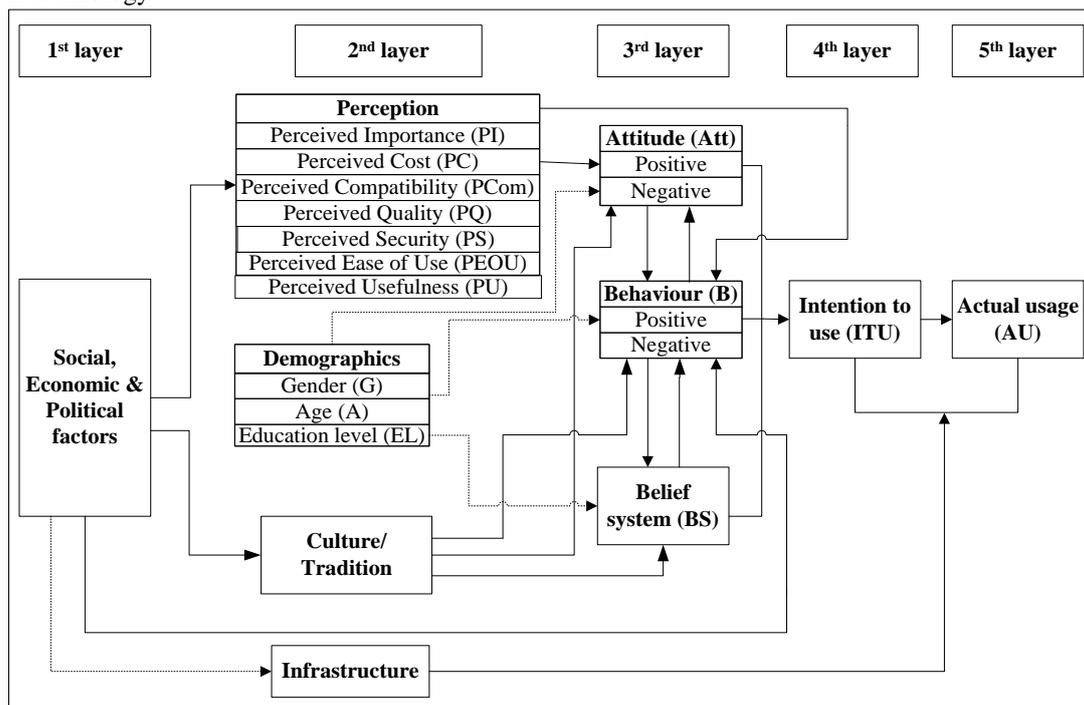
Gaps in previous studies, theories, and models necessitated the development of UTAUT by Venkatesh et al. (2003). According to Duarte and Pinho (2019), earlier models such as TRA, TAM, Motivational Model (MM), TPB, and IDT informed the development of UTAUT, which has superior explanation power compared to these well-established models (Lee & Rho, 2013).

UTAUT is grounded in four constructs that influence user behavioral intention predictors and actual technology usage: effort expectancy, performance expectancy, facilitating conditions, and social influence (Bradley, 2009; Lai, 2017). The model also has four moderators: age, gender, experience, and voluntariness (Duarte & Pinho, 2019). Effort expectancy controls perceived ease of use of technology, while performance expectancy constitutes perceived usefulness, job fit, extrinsic motivation, relative advantage, and system outcome expectancy (Lai, 2017). Performance expectancy thus is defined as the degree to which using systems and technology help users perform certain activities (Al-Qeisi et al., 2014). Facilitating conditions define user perceptions of the infrastructure, resources, and support available from service providers and governments to perform behaviors, such as using systems whenever necessary (Shaikh, 2016). Similar to the antecedent subjective and social norms in TRA introduced by Fishbein and Ajzen (1975), social influence is the extent to which consumers believe that important others (family and friends) think they should use particular technology and systems (Brown & Venkatesh, 2005; Venkatesh et al., 2003)

Recently, Venkatesh et al. (2012) proposed a revised model, UTAUT2, which includes three new constructs: hedonic motivation, price value, and habit (Duarte & Pinho, 2019). The combination of UTAUT and UTAUT2 is intended to predict human and user behavioral intentions regarding technology usage from the perspective of Performance Expectancy (PE) (Chang, 2012). We are applying both yields predictions based on a better understanding of the issues that facilitates technology and system adoption.

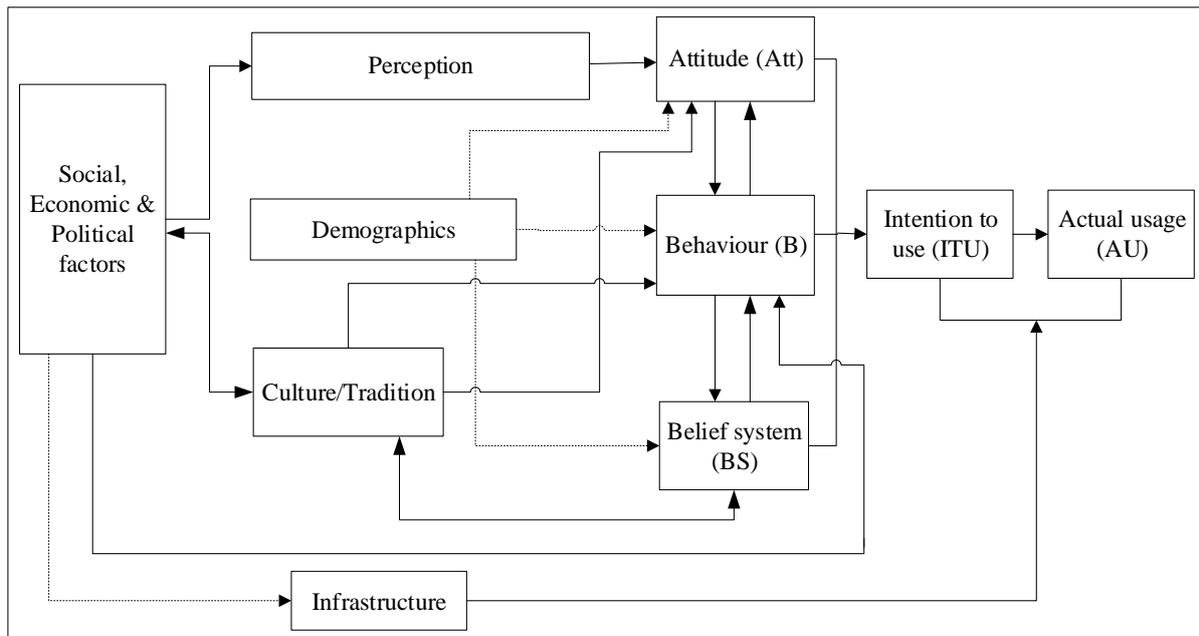
**DEVELOPMENT OF THE REVISED TAM**

As seen in Figure 2, the revised TAM holds that actual technology adoption is determined by technology’s constructs and components. The revised TAM focuses on grassroots factors and constructs that define individual and organizational ideas, concepts, perceptions, attitudes, behaviors, and intentions to use culture-embedded cutting-edge technology. The TAM is primarily suitable for developing and emerging countries but can also be applied to developed countries. As observed, existing models, theories, and frameworks are generic in nature, whereas the revised TAM is specific. Many users adopt technology for various reasons, so these models, theories, and frameworks (Figure 1) are aimed at determining user intentions, behaviors, and actual adoption and usage of technology, applications, and systems. However, none or few of these models, theories, and frameworks focus on the indigenous technology characteristics of users in middle-income and developing countries as a means to deliver culture-oriented technology (culture-tech). Companies often invest in new technology when users are not ready to adopt it (Bradley, 2009). The revised TAM, therefore, could be useful to avoid unacceptance, resistance, and rejection of investments in technology.



Source: This study.

Figure 2: Revised technology adoption model (TAM).



Source: This study.

Figure 3: Revised technology adoption model (TAM), abridged.

As shown in Figure 2, the revised TAM is divided into five layers intended to organize and group the model into independent but connected structures. The connections are illustrated with arrows. Bolder arrows indicate strong relationships, and dotted arrows show weak, variable relationships, meaning that demographic factors and their associated constructs may or may not influence each other. Developing countries face social, economic, and political challenges such as a lack of infrastructure that directly and indirectly affect the wellbeing of consumers, users, and citizens. As technology evolves, these three factors, along with infrastructure, are the main motivations for individuals and organizations to adopt and use cutting-edge technologies. The three factors are the most challenging issues confronting developing and emerging countries in the 21st century.

The first layer in the revised TAM consists of enablers driving user perceptions, cultures, and traditions surrounding technology in middle-income and developing countries. The second layer encompasses perceptions alluded to by TAM and other components missing from existing theories, models, and frameworks that define the individual attributes determining technology acceptance in developing and emerging countries. An abridged revised TAM in Figure 3 provides a summary of Figure 2 to simplify the understanding of the model for readers and developers.

### First Layer: Social, Economic, and Political Factors

Research has proven that technology adoption depends on more than user attitudes, and the modified TAM2 suggests that external variables influence technology adoption but does not analyze these variables in depth (Lai, 2017; Talukder, 2012). Thus, in Figure 2, social, economic, and political factors are the first layer in the adoption of technologies, applications, and systems, especially in developing and emerging countries. This layer is a determinant in technology adoption predictor processes (Chieochan, Lindley & Dunn, 2000). To elaborate, social factors directly affect technology adoption by individuals through societal and natural changes within their environments (Friederike et al., 2017). In this study, social factors and attributes influence the existence of a person; however, the culture and its attributes direct and guide social factors in developing and emerging countries.

Economic issues directly influence technology use. In a scholarly explanation (Kipsoi, Chang'ach & Sang, 2012), economic factors are monetary issues that affect buyers' decisions regarding satisfying buying expectations. These factors involve initial spending and returns on investment. Kipsoi et al. (2012) proposed that economic crises can reduce individual spending capacity, so economic factors are determinants of technology innovations and device purchases. However, middle-income and developing countries are financially insufficient, restricting their actions and purchasing power. In this paper, economic issues encompass monetary issues that affect individual buying power to acquire new technologies.

Political factors are government policies, legislation, and actions that guide citizens. The quest to adopt technology raises political questions. The government ensures the environment necessary to acquire, access, and use technology for social and economic improvements (Ejiaku, 2014). A peaceful, suitable government or good governance promotes and provides a happier society, which enables citizens to explore new and existing innovations and vice versa. According to Friederike et al. (2017), political factors involve policies and legislation that influence technology development and adoption. This paper follows the definitions of political factors from Ejiaku (2014) and Friederike et al. (2017). Research has shown that developing countries are poor at

forming innovative technology policies (Ejiaku, 2014). The researcher further believes that governments in developing countries might recognize their weak policies but still do nothing to address them.

### **Second Layer: Perceptions, Demographics, Culture, Traditions, and Infrastructure**

The second layer consists of the perceptions, demographic characteristics, cultures, traditions, and infrastructure that are important influences on the adoption of cutting-edge technology by those in middle-income and developing countries. These independent variables shape define user intentions to use and adopt cutting-edge technology in developing countries.

Perceptions refer to individual views on the adoption of cutting-edge technology. The perceived components of technology are importance, cost, compatibility, quality, security, and ease of use. These components are intrinsic in the nature of adopting technology innovations.

#### ***Perceived importance***

This component refers to the extent to which individuals feel that adopting technology will improve their activities (Fathema, Shannon, & Ross, 2015; Sharma & Chandel, 2013; Sharma & Mishra, 2014; Venkatesh & Bala, 2008). Perceived importance is significantly influenced by social and economic factors. Generally, potential users of technology in developing and emerging countries consider its importance to advance knowledge and ideas and to fulfill desired aims and expectations. Perceived importance thus is the positive belief that cutting-edge technology will effectively improve personal-life activities based on social and economic factors.

#### ***Perceived cost***

Cost-benefit and cost-to-purchase ratios affect the adoption of cutting-edge technology (Friederike et al., 2017). Users believe that technology costs play a determinant role in the adoption process (Nyagar, Korir & Nyangweso, 2017). Friederike et al. (2017), due to economic challenges confronting middle-income and developing countries, their citizens often experience financial instability and have limited purchasing power for advanced technology. They face a dilemma of whether to acquire basic commodities and technology. This paper draws on the idea of Friederike et al. (2017) that perceived costs affect the ability to acquire technology in developing and middle-income countries. High costs may deter acquiring new technology, while low costs may encourage it.

#### ***Perceived compatibility***

This component refers to the compatibility of technology with personal cultures and traditions and the accomplishment of tasks. Potential users need to determine technology compatibility before making decisions. Positive assessments of compatibility promote better attitudes. In this paper, the perceived compatibility of technology determines whether users adopt it.

#### ***Perceived quality***

This component refers to the degree to which individuals believe that technology will last for a long time and achieve the desired expectations. Perceived quality further relates to the quality and standard of technology. Researchers have viewed perceived quality as assessments of actually desired features (example, reliability, system response time, adaptability, and availability (Fathema et al., 2015). The researcher also suggests that potential users evaluate cost against quality, and economic conditions determine whether users acquire good-quality devices. In this study, therefore, quality is a determinant of technology adoption behaviors.

#### ***Perceived security***

This component refers to the extent to which technology is considered to be secure. Personal security plays a very important role in individual technological adoption, as it involves personal particulars. Security concerns shape user attitudes, and Lai (2017) argued that security concerns, directly and indirectly, affect user intentions. According to the stimulus theoretical framework, security is a function of perceived usefulness and ease of use (Lai, 2017). In this study, it is essential to consider personal security in technology adoption as personal information should be secure and confidential. Personal security thus deals with safety considerations that further affect behaviors, intentions, and actual technology adoption.

#### ***Perceived ease of use***

This component influences the main concerns in technology adoption (Friederike et al., 2017). It refers to the personal judgment that technology can be used effortlessly to execute tasks (Fathema et al., 2015; Sharma & Chandel, 2013; Sharma & Mishra, 2014). The easier using technology is perceived, the more likely users are to adopt it. Users have high chances of adopting technology that they perceive as easy to use effortlessly. Citizens in middle-income and developing countries thus prefer to see that it is easy to use technology to meet their needs and expectations. Users' general belief systems are positive determinants of the perceived ease of use of systems (Venkatesh & Bala, 2008), while, in turn, defining the behavioral intention (BI) and actual usage (AU) of cutting-edge technology (Bradley, 2009).

#### ***Perceived usefulness***

This component refers to end users' belief that a new technological platform will advance and support their daily activities (Lai, 2017; Lim & Ting, 2012). According to Davis (1989), perceived usefulness improves confidence in information technology's capacity to improve individual job productivity, effectiveness, and performance. Perceived usefulness supports high levels of

internal consistency and competence in users (Legris, Inghamb, & Collerettec, 2003). Beliefs motivate users' adoption of cutting-edge technology in developing and emerging countries. Their beliefs also define their technology adoption attitudes and behavioral intentions (Bradley, 2009). In this study, perceived usefulness is believed to be a determining factor in the perceived ease of use of technology.

### **Demographics**

The factors affecting technology adoption encompass demographic characteristics and direct personal attributes. The demographic characteristics in the second layer of the revised TAM include gender, age, and education, among others. These demographic factors indirectly (see the dotted lines in Figures 1 and 2) affect user attitudes, behaviors, and belief systems regarding the adoption of various products, services, systems, applications, and technologies such as smartphones.

Gender is a personal attribute organized into males and females and affects individual social consciousness and actions. This factor influences the adoption of cutting-edge technology, which affects its positive actual or final usage (Bradley, 2009). Lee et al. (2003) suggested that gender controls social factors, perceived importance, and perceived ease of use. However, Bradley (2009) stated that gender has no direct impacts on perceived importance and perceived ease of use related to technology adoption. In this paper, gender is held to affect individual attitudes, behaviors, and belief systems toward cutting-edge technology adoption.

Age is a crucial demographic factor in technology adoption, especially in middle-income and developing countries where older generations are tech-naïve and younger generations are tech-oriented (Friederike et al., 2017). Older generations must adjust to technology, although age cannot hinder interest in technology adoption (Friederike et al., 2017). In this paper, age is treated as a crucial determinant of the adoption of cutting-edge technology. Younger generations are more tech-oriented than older generations, so individual age affects technology adoption. Age can be a determinant of behaviors and intentions.

In another fundamental influence on users' technology attitudes, increasing education levels foster positive attitudes toward cutting-edge technology (Friederike et al., 2017). It can be confirmed that, in general, the education levels of citizens in middle-income and developing countries affect their attitudes toward cutting-edge technology (Friederike et al., 2017). Individuals' education levels shape their technology acceptance attitudes.

### **Cultures and traditions**

The Merriam-webster.com dictionary defined culture as "the set of shared attitudes, values, goals, and practices that characterizes an institution or organization."(merriam-webster.com, n.d). While Chukwuere, Mavetera, and Mnkandla (2016) described culture as the common values, knowledge, industries, talents, and civilization connecting people in a particular environment. These values and knowledge control the systematic norms of how people view and accept knowledge (Lekhanya, 2013; Chukwuere et al., 2016). Technology is not a historically inherited device in developing countries, so for it to be adopted and used, developers must understand and recognize users' cultural values and standards (Lekhanya, 2013). Accordingly, Lekhanya (2013) believed that a society's culture is fundamental to the acceptance of technological innovations in middle-income and developing countries. This statement shows that culture is regarded as a key element in human expression (Lekhanya, 2013). In this study, culture controls and influences users' views, actions, and perceptions of the use and adoption of cutting-edge technologies.

Traditions can be referring to long-standing "cultural practices" by groups of people in a given society (Maluleke, 2012). Cultures and traditions involve history, language, lifestyle, values, food, and dressing patterns. These long-standing values can be changed, not overnight but through a gradual process. Such practices in the dominant culture can spur resistance to technology adoption and use. Overcoming this barrier to deliver technology innovation can be complex, but developers should seek to understand these barriers through this innovative model. Cultural elements influence the chances of technology adoption (Lekhanya, 2013). In this study, cultures, traditions, and social, economic, and political (SEP) factors mutually influence each other. Furthermore, cultures and traditions influence perceptions, behaviors, and belief systems, which are fundamental individual predictors of the adoption of cutting-edge technology in middle-income and developing countries.

As Figure 1 illustrates, infrastructure is an enabler of use intentions and actual technology usage. In Figure 6, a dotted line connecting SEP factors and infrastructure indicates a partial relationship. The connection mainly shows that economic and political factors may affect technology infrastructure development and standards in developing countries.

### **Infrastructure**

Technology infrastructure involves computers, Internet access, software, and other components (Ejiaku, 2014). Standard infrastructure affects engineers' positive intentions to use and adopt technology in middle-income and developing countries. Kipsoi et al. (2012) argued that infrastructure in middle-income and developing countries falls below standards and fails to promote technological innovations. The lack of infrastructure includes high Internet costs, unreliable computer equipment, and a lack of telecenters, a steady power supply (electricity), and technical support in communities, among others. Access to technology infrastructure is low; for example, only 1% of people in Africa use the Internet (Kipsoi et al., 2012). Poor infrastructure conditions make access to information costly and limited. Technology infrastructure lags behind due to poor government policies and limited investment (Ejiaku, 2014). In this study, infrastructure is a function of technological adoption.

### **Third Layer: Attitudes, Behaviors, and Belief Systems**

The third layer encompasses user attitudes, behaviors, and belief systems regarding technology adoption in developing countries. Attitudes refer to positive and negative beliefs about carrying out particular behaviors (Chuttur, 2009). Sharma and Mishra (2014) defined attitudes as the degree of belief in certain behaviors, while Lai (2017) viewed attitudes as personal assessments of objects. User attitudes toward technology are a function of technology's perceived importance and ease of use, which shapes real behaviors (Fathema et al., 2015). Attitudes toward technology are affected by user beliefs, use intentions, gender, age, education levels, and general behaviors. Before developing positive attitudes, users must develop good intentions. In this study, attitudes determine behaviors, which affect beliefs.

Behaviors are the "result or intention" of attitudes (Lai, 2017). In this study, behaviors can be positive or negative and are measured by their frequency, duration, number, and multiplicity of use (Lee et al., 2003). Behaviors determine what a person would like to do (attitudes) and think should be done (social norms; Sharma & Mishra, 2014). Positive behaviors affect users' intentions to use technology, while negative behaviors promote anxiety regarding technology (Sharma & Mishra, 2014). Figure 6 shows that behaviors can be positive or negative, influencing actual behaviors toward technology adoption. Sharma and Mishra (2014) further believed that behaviors are influenced by outcome expectations and performance outcomes. Behaviors are intentional influences on user technology adoption. Furthermore, behaviors are driven by perceived importance and ease of use (Venkatesh & Bala, 2008). Consequently, individuals' belief systems determine their personal behaviors toward technology.

Belief systems are the cognitive aspect of individual attitudes (Sharma & Mishra, 2014). Lai (2017) defined beliefs as associations between objects and attributes. Beliefs draw upon two aspects of behavioral intention: perceived importance and perceived ease of use (Venkatesh & Bala, 2008). In this study, beliefs are considered to be elements of personal cultures, traditions, demographics, and behaviors that shape perceptions of technology. Beliefs are also a state of belief in something. Any personal belief about technology can be influenced by factors, including society, economics, politics, infrastructure, culture, and traditions.

### **Fourth Layer: Intentions to Use**

Intentions to use compose the fourth layer of the revised TAM that encompasses the intrinsic aspects of a person. Personal intentions are defined as individual behaviors that shape intentions to use (Fathema et al., 2015). Regarding the revised TAM and ITU, cutting-edge technology depends on the behavioral change of a user, which is a function of personal attitudes, behaviors, beliefs, and infrastructure. In this study, intentions to use are the main motivations for the use of cutting-edge technology to accomplish personal and organizational tasks.

### **Fifth Layer: Actual Usage**

Gaps in previous studies, Actual usage forms part of the fifth and final layer of the revised TAM and is defined as the actual use or adoption of technology innovation by individuals or organizations. The effective functioning of the fifth layer is entirely dependent on the first, second, third, and fourth layers. Both layers promote better actual usage of any technology in middle-income and developing countries. The layers components are a function of behavioral intentions to use technology (Bradley, 2009). In this study, the actual usage is the act of the effective application of technology to achieve the desired aims. Actual usage shows that individual use of any system results from individual changes in behaviors that lead to final usage.

In summary, in the revised TAM, cutting-edge technology's actual usage and adoption are functions of SEP factors, perceptions, demographic characteristics, cultures, traditions, infrastructure, attitudes, behaviors, belief systems, and intentions to use (see Figure 1).

## **APPLICATIONS OF REVISED TAM**

The main purpose of the application of technology acceptance models and theories to IS and other disciplines over the decades has been to determine the influence of users' behaviors in technology adoption. The revised TAM, in particular, is intended to assist middle-income and developing countries' users and organizations in adopting cutting-edge technology. The revised TAM has broader applicability as it is more current and concise based on in-depth analysis and evaluation of the different models and theories applied in social sciences research and in real life. The revised TAM is more robust for use and applicable across countries and contexts, especially middle-income and developing nations.

The revised TAM has various applications. First, it can be applied to given populations based on country, community, demographic characteristics, social group, educational institutions, and other factors. The revised TAM is intended to understand the underpinning factors of users' behavioral intentions that affect the adoption of cutting-edge technology, particularly in middle-income and developing countries. The revised TAM is well suited to analyze technology-associated behavioral intentions and actual use of technology and systems. Second, the revised TAM can be vital for researchers investigating and applying technology adoption models and theories to understand cultural and general factors and components that affect acceptance of technology and computer-related systems in middle-income and developing countries.

Third, the revised TAM can be applied across academic disciplines (e.g., the social sciences, education, and humanities) and organizations to evaluate technology-related contexts. Moreover, the model is intended to deliver consumer-oriented technologies within culture-tech contexts and markets.

## CONCLUSION

Developing countries often confront social, economic, and political challenges and a lack of infrastructure, which hamper the diffusion of technological innovations. In recent decades, many models and theories have been developed to identify the factors that determine individual acceptance and continuous usage of technology. This literature review served the purpose of developing and proposing a revised TAM that describes the factors and layers that affect the adoption, usage, and diffusion of technology, applications, and systems in developing and emerging countries. These factors and components are essential to promote culture-tech initiatives as the underpinning cultural factors are regarded as impediments to technological adoption in developing and emerging countries and, therefore, should be considered. The application of the revised TAM by technology developers will promote the inclusion of the personal, social, economic, and political attributes of users in developing and emerging countries. The revised TAM considers and integrates issues pertaining to users in developing and emerging countries.

## THEORETICAL CONTRIBUTIONS AND LIMITATIONS

This study is not without limitations. The revised TAM can be regarded as a conceptual idea that researchers can apply to determine its effectiveness at managing the adoption of technology, applications, and systems, specifically by users in developing and emerging countries. The proposed model is yet to be tested but is empirically relevant. In summary, it is recommended that the revised TAM components should be thoroughly tested to determine their effectiveness in real-life technology development, design, and adoption and in academic and scientific research.

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## UML Artefacts for a Blockchain-enabled Platform for Fairtrade.

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### ABSTRACT

Fairtrade-certified products have successfully entered the mainstream distribution channels, mostly in developed countries, and these products are now sold in famous supermarket chains. Nonetheless, the packaging and labeling of products as “Fairtrade” command premium pricing in the marketplace. How much of this, however, is valid and justified? Despite the reputable certification mechanisms for quality assurance, mass media reports suggest that much of the “surplus value” goes to the accreditation agencies themselves instead of the producers. This article proposes an agenda to set this right with a blockchain platform that provides “trust-free” assurances of verifiable labeling. Using an Action Design Research methodology, we have specified a research prototype of a Blockchain-enabled Fair-Trade platform Unified Modelling Language artifacts. We believe this will set the direction for social inclusion as part of information systems scholars’ aspiration to promote “tech for good.”

*Keywords:* Fairtrade, blockchain, digital platforms.

### INTRODUCTION

Consider a socially aware consumer wishing to make informed choices about the products and services (s)he consumes, such as organic jasmine rice (see Figure 1). How does the consumer determine the trustworthiness of the product labels when paying a premium price? For example, the organic rice shown in Figure 1 costs about 50% more than its equivalent in a mainstream grocer. This is typical of the dilemmas that food consumers face at outlets such as grocery stores, cafés, restaurants, and e-tailers; myriads of certifications (e.g., “organic,” “FT,” “non-GMO,” “rainforest alliance,” “halal,” or the one shown in Figure 1 below) confront the choice that they have to make. Implicit in that choice is consumers’ “trust” in the brands and merchants. In many cases, there is a trusted third party (TPP) that authoritatively certifies a product by attaching the corresponding label (e.g., AsureQuality in New Zealand) on it, and that regulates the entire supply chain network, from production to commercialization. However, even with a trusted source, many consumers often wonder if they are paying an excessively high price for certification.



Figure 1: Buying with trust and confidence.

The aforementioned doubts are, in fact, warranted and provided an opportunity for a digital venture that unlocks value (Sharma et al., 2010). According to a study about the production of flowers, coffee, and tea in Ethiopia and Uganda, which was commissioned by the U.K. government and has been widely reported (Vidal & Provost, 2014), the sale of FT-certified products failed to benefit the poor farmers in such countries. The wages of the farmers in the farms that grew FT flowers or who sold coffee and tea to FT-certified markets were lower than those of the farmers in the larger commercial farms that were not FT certified (Vidal & Provost, 2014). In Marxist parlance, should the surplus value generated by “Fairtrade” go to the needy producer or to the exploitative distributor? What if the entire producer-distributor-consumer chain can be placed on a “trust-free” platform where open data are transparent, traceable, tamper-resistant, immutable, and compliant (the so-called 3TIC characteristics)? Such a “3TIC” mechanism (Sharma et al., 2019; Jahanbin et al., 2019) will also allow FT producers and distributors to create and capture the value that they bring to the marketplace (Crosson et al., 2019).

This brief investigates the application of blockchain and augmented technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big-data analytics in creating a platform that does not require the overhead of a Trusted 3<sup>rd</sup> Party (TTP) for a digital FT platform. Blockchain (also called the distributed ledger) has grown in prominence in recent years. It is defined by Technopedia (n.d.) as a list of records linked together using cryptography, where the records (called blocks) contain the record data and a cryptographic hash to the previous block in the chain. According to the same source, the cryptographic hash is created using the record data, and changing any data will render the link to such data invalid. Technopedia (n.d.) claims that this data-linking mechanism ensures a secure record history as a record cannot be changed without also changing all the subsequent blocks attached to it (collectively called an immutable ledger). While value analysis has been performed for cryptocurrencies (cf. Wingreen et al., 2020), this business issue has sparsely received scholarly attention. At a conceptual level, there is a certain elegance to a blockchain-based FT platform that (1) provides 3TIC assurances to savvy consumers that the premium prices they are paying are justified and (2) allows producers mostly from non-Western countries to enter into simple contracts with distributors with low legal costs (Kshetri et al., 2021). However, little empirical support is available for such a use case from field trials that will give confidence to digital entrepreneurs to launch such a venture.

#### FAIRTRADE PLATFORM DESIGN AND METHODOLOGY

Blockchain-enabled platforms have socio-technical characteristics; hence their affordances could be analyzed using appropriate methods from systems thinking. The configuration of a scalable, non-TTP platform using design science research (DSR) begins with understanding the socially desirable latent needs of consumers and then proceeds to develop a technically feasible proof-of-concept (PoC) design with the 3TIC principles that address the “what” question and the derivative design rules that address the “how” question. As an example, for the principle of tamper resistance, the use of IoT technologies such as unique QR (quick response) codes that “self-destruct” to be rendered non-reusable may be adopted as a design rule to achieve the aforementioned principle. The PoC design is then validated by determining if it is economically viable as an innovative solution to the business or industry problem. A number of blockchain development environments are commercially available, and for familiarity and experience, Ethereum (an open-source environment recently acquired by Microsoft) and IBM’s HyperLedger Fabric were considered for adoption in this work to develop and validate a PoC design.

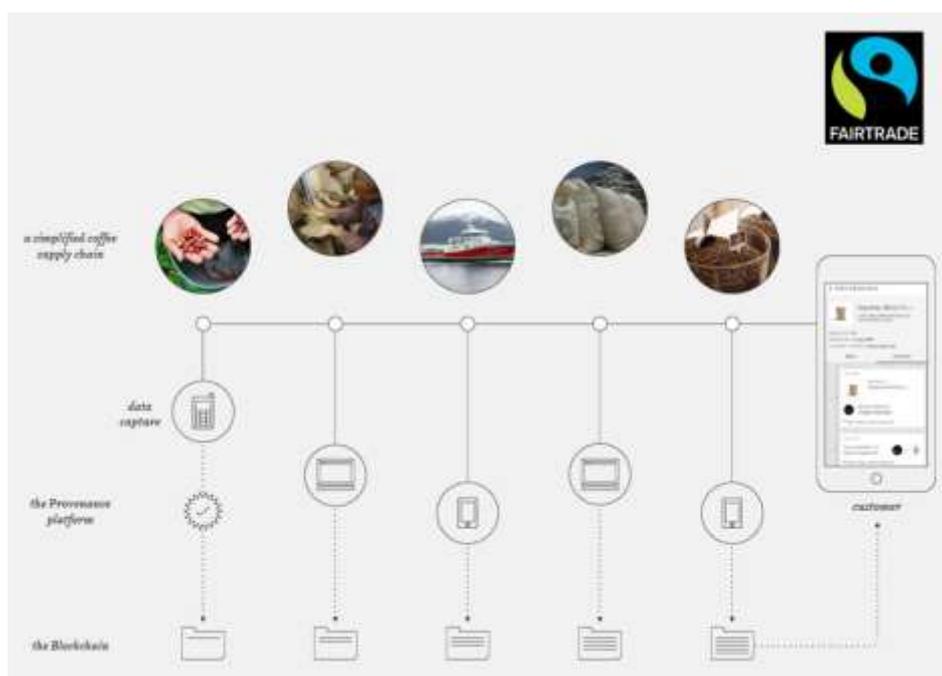


Figure 2: The blockchain FT Platform with five steps.

For example, for FT coffee or cacao, there are typically five sets of data that a blockchain platform must be able to record or provide for it to be feasible (see Figure 2), as follows: (1) at the farm, the source, destination, grade, and purchase date of the beans; (2) during the processing, the identity of the processing plant, the specific processes performed, and the quality checks made and their dates; (3) in the course of the shipment, the carrier, route, and arrival and receipt validation dates; (4) during the wholesale or retail packaging, the required label with regulatory and consumer information; and (5) at the time of purchase, the QR code that a consumer should be able to scan to confirm that the label is authentic, especially with regard to FT. It is, therefore, evident that a 3TIC blockchain platform for FT will work only if all its component data can be trusted and verified. The use of IoT devices and other tamper-resistant technologies (e.g., QR code stickers on the produce) augments the blockchain records.

Three research issues need to be addressed to provide a minimum viable solution for the blockchain-enabled FT platform. The first is the issue of scalability. Blockchain solutions are regarded as computationally expensive and may not be feasible or viable in public (permission-less) marketplaces with thousands of producers and distributors and millions of consumers. A DSR approach will allow hybrid or private (permissioned) architectures with various transaction or block verification configurations (e.g., proof of work [POW], importance, or stake) to be field-tested.

The second research issue is privacy. In conflict with data protection legislation (e.g., the EU General Data Protection Regulation), blockchain solutions can allow the identification of producers, their products, and prices, and such publicly available information may be mined to profile the consumers.



Figure 3: QR code sticker for tamper-evident authentication.

Design rules for a hybrid architecture that partitions off-chain data (e.g., personally identifiable information and other sensitive data) and that allows the “right to be forgotten” should be explored.

The third research issue is trust. This “grand” research issue concerns the sound and rigorous validation of the PoC that will generate trust and confidence from the producers and consumers in the FT marketplace. The current practices of using AI-based or crowdsourced recommendation or suggestion systems have been revealed to be manipulated and flawed (Sharma *et al.*, 2021). Practices of using such systems thus remain a gap in the current marketplace, which may be addressed by a DSR approach.

When the above three issues are taken as design parameters for an FT platform, the validation of the PoC will have an entrepreneurial impact on how producers and consumers interact to create and capture value in the FT marketplace. This will be another use case of an inclusive digital enterprise that promotes demonstrable innovation with digital technologies.

### Use Case of an FT Platform

The scenario depicted in the previous section is not a toy problem. The lack of a “trust-free,” verifiable platform has, in fact, inhibited the perceived affordances of FT as an opportunity for socio-economic inclusion. Trade Aid ([www.tradeaid.org.nz](http://www.tradeaid.org.nz)), founded in 1973 by the Christchurch couple Vi and Richard Cottrell, is a Kiwi social enterprise that seeks to create fairness in trade by partnering with small food and craft producers around the world. Its vision is to support and educate Kiwi consumers to join in creating a world where trade is fair for all. This is philosophically identical to another well-known voice for fair and green: The Body Shop, founded by the late Anita Roddick in 1976 in the belief that business could be made a force for good. Social enterprises are businesses with a social purpose that are run along commercial lines so as to be sustainable for all the stakeholders. In other words, aside from being a sustainable and financial trading company, Trade Aid is managed in such a way that all the business decisions made will be good for the people it works with.

From the time the founders of Trade Aid gathered their friends and cleared out their garage in preparation for artisan handcraft shipments from around the world, Trade Aid started as a social enterprise in 1973, much before the notion of social entrepreneurship was popularized. To this day, no one owns Trade Aid, or maybe everyone owns Trade Aid, particularly the New Zealanders working together to achieve equity for all. Since its inception, Trade Aid has been wholesaling select craft and organic food products to hundreds of other Kiwi businesses, which were welcomed into the FT family of businesses. It is a *whānau* that puts people over and above all else, Kiwi businesses that know that it matters who the producers are and that they

are being treated ethically. In short, the FT platform supports an entrepreneurship ecosystem in which each contributor to a final product or service derives a fair return from the venture. Since the year 2020, however, the retail outlets for Trade Aid products have often been confronted with informed and skeptical consumers who require more than a label to be assured of FT and quality. This is to be expected given the preponderance of such marketing messages and of social entrepreneurship. While a product like the one in the photo on the next page may have been a radical innovation in the 1970s, it is now part of the millennial mainstream. Millennial consumers consistently choose sustainability over the price per se.

Trade Aid, Vittoria, and The Body Shop franchise are examples of social enterprises that live out the Maori adage “HE AHA TE MEA NUI O TE AO. HE TĀNGATA, HE TĀNGATA, HE TĀNGATA,” which translates to “What is the most important thing in the world? It is people. It is people. It is people.” In the present millennium of socially aware consumers, legislation has attempted to keep abreast of all the sentiments about ethical commerce. In the United States, iTSCI was established in response to the Dodd-Frank Wall Street Reform and Consumer Protection Act, which requires U.S. companies to vet their supply chains. Specifically, section 1502 of the Act requires resource-mining companies to disclose if they source conflict minerals such as tin, tungsten, tantalum, and gold from the Democratic Republic of Congo and/or nine other countries considered “hotspots.” iTSCI’s “bagging and tagging” system is an example of a traceability scheme in non-blockchain supply chains and involves a five-step due-diligence framework.



Figure 4: Product label traceability.

Internationally, there are suggested remedies. Given its troubled past, the Modern Slavery Act 2015 in the United Kingdom aims to fight modern-day socio-economic slavery. This law requires organizations conducting business in the U.K. with worldwide revenues of at least £36 million to publish a transparency statement explaining the steps that they took in the previous financial year to ensure that their business and supply chains would be free from indentured labor and human trafficking. The British embassies in the Association of Southeast Asian Nations member countries funded the eMin tool to track contract workers in the maritime fishing industry and to compel them to comply with the aforementioned law. This blockchain-based mobile app (<https://www.eminproject.com/>) is used to store copies of employment contracts for workers in the maritime fishing industry and other aquacultural sectors. Employment contracts and related data are stored on the Ethereum platform, and both workers and employers can access their contracts, which will give them a basis for adjudicating the rights and benefits that were offered to them at the time of their recruitment. A blockchain platform augmented with smart contracts that enforce producer rights and fair pricing can enforce compliance with such legislation, which, after all, can only be as effective as its enforceability.

### Ethereum Proof of Concept

At this exploratory stage of our DSR study, a PoC comprises Unified Modeling Language (UML v 2.0) design artifacts, which served to clarify the research understanding of the context, use cases, and sequences. Some of these artifacts are given in the Appendices.

A considered choice was made to use the Ethereum platform (rather than HyperLedger) for the development of the PoC. Ethereum is an open-source environment and has functionalities for smart contracts that run on top of it. Therefore, Ethereum is a public blockchain that offers a decentralized virtual machine providing smart contracts for private or permissioned blockchains. While Ethereum has one of the most extensive cryptocurrency offerings, with hundreds of private blockchains globally, it does not have an installed database larger than that of HyperLedger. To go around the scalability and interoperability issues of blockchain, IBM has partnered with Ethereum to build a blockchain platform that is more powerful than either Ethereum itself or HyperLedger. Moreover, while HyperLedger is a private blockchain that is currently in the beta stage, it offers features similar to those of the Ethereum blockchain but in a more sophisticated and secure manner. As it is used only for enterprise-level purposes and not by cryptocurrency miners or crypto-investors, it is considered a more serious platform. HyperLedger has such a reputation because it is very fast and scalable as it was built specifically for enterprise use, whereas Ethereum was built as an open-source, public blockchain. IBM also plans to integrate its own cross-chain system into

the unified blockchain platform, allowing the exchange of different cryptocurrencies without using an exchange or third-party agent.

To obtain an initial understanding of the requirements of a blockchain-enabled FT platform, a context diagram was developed using UML. This is shown in Appendix A. Subsequently, a typical use case was discussed. Both the context and use case diagrams serve as design artifacts for clarifying the requirements of the specifications for the later development of the PoC. To represent the dynamic behavior of the FT platform, the use case diagram was made to include the significant actors and typical scenarios and their relationships. All the major internal and external influences were incorporated so that the system's interaction with other entities could be explicitly displayed. The functional requirements were translated to represent the major tasks and operations in a systematic manner, in accordance with the standard supply chain procedures. The standard UML naming convention was followed for easier identification and understanding of events and their flow of logic. The diagram was repeatedly refined to achieve a well-structured system depiction.

Appendix D shows the UML sequence diagram of how the concept of blockchain technology using the Ethereum platform may be used in supply chain management for fair trading. All the main actors of the supply chain are duly represented: the producer (manufacturer), distributor (the one who packages the product), reseller (the one who sells the product to the consumers), consumer (buyer), validator (the one who validates the blocks), and approver (the one who provides the FT label). The cycle begins when a coffee-roasting enterprise known as ABC Company, for instance, signs the smart contract. The smart contract comprises the digital terms and conditions that should be accepted before performing any transaction inside the blockchain network. This process focuses on the transaction between the seller and the buyer. The steps below will further elaborate on the sequence of steps necessary to establish the setup of this technology.

1. The smart contract has to be accepted by the producer, distributor, and resellers of the FT produce (i.e., coffee). For this, the digital contract is shared, and an agreement is received from all the parties.
2. Before buying the product, the consumer will scan a QR code, for instance, and the shared contract will be matched to the seller to initialize the transaction. In parallel, the transaction will also be performed by the seller.
3. At the same time, the transfer of assets (coffee beans) associated with the smart contract and the transaction will be certified by the approver. If the assets match the smart contract, the approver will store the transaction records in the shared ledger.
4. When the transaction is performed, the other parties in the distribution chain will also be notified, and storage will be done after the transaction is approved.
5. As the payment gateway is enabled for the transfer of the money from the buyer to the seller, the blocks are updated and retired.

Preliminary experience suggests that the approach suggested above is potentially feasible. As a next step, a pilot implementation will be validated in the field for FT merchants such as Trade Aid.

### **CONTRIBUTIONS TO DIGITAL ENTERPRISE RESEARCH**

The validated findings will contribute to digital innovation and enterprise researchers' theoretical understanding of the affordances of blockchain and augmented technologies in addressing the challenge of generating trust in the marketplace. While research on trust is a long-standing market research tradition, never has the idea of a distributed autonomous organization been applied to co-opt confidence and participation in a digital platform. A practical outcome would be that the PoC will demonstrate the basis for scaling up the platform to include a larger community of producers, distributors, and consumers. While this may be applicable to a host of other labels for halal, sustainable, environment-friendly, or organic food, the key theoretical and practical contribution of the present research will be to make the digital marketplace for food more inclusive to producers who wish for FT.

As MIT's 2018 Platform Strategy Summit declared, "Everywhere there can be a platform, there will be a platform." The summit closed with three value propositions for the use of blockchain: (1) improving efficiency, security, and transparency in traditional businesses; (2) reducing transaction friction across platforms; and (3) adding new revenue streams in the form of payments and efficient ways to transfer value. The above represent opportunities for a digital venture. Natarajan *et al.* (2019) have performed an extensive field study of middle-management involvement in the adoption of technology platforms for addressing distribution and compliance challenges. It is clear that a blockchain platform will also need to confront a host of stakeholder issues to become effective. Investigating managerial challenges and deriving suitable solutions is, therefore, another fruitful avenue for further research.

A platform strategy of future work can scale to include scenarios that inter-operate with other labels, such as halal, rainforest-friendly, sustainably produced, and 100% NZ Pure (BBC, 2019). Another fruitful avenue for entrepreneurship research is the market's acceptance of appropriate verification and consensus mechanisms such as POW (Technopedia, n.d.) on the blockchain platform. Then authentication of the labels of quality assurance, composition, or origin and consumer ratings and

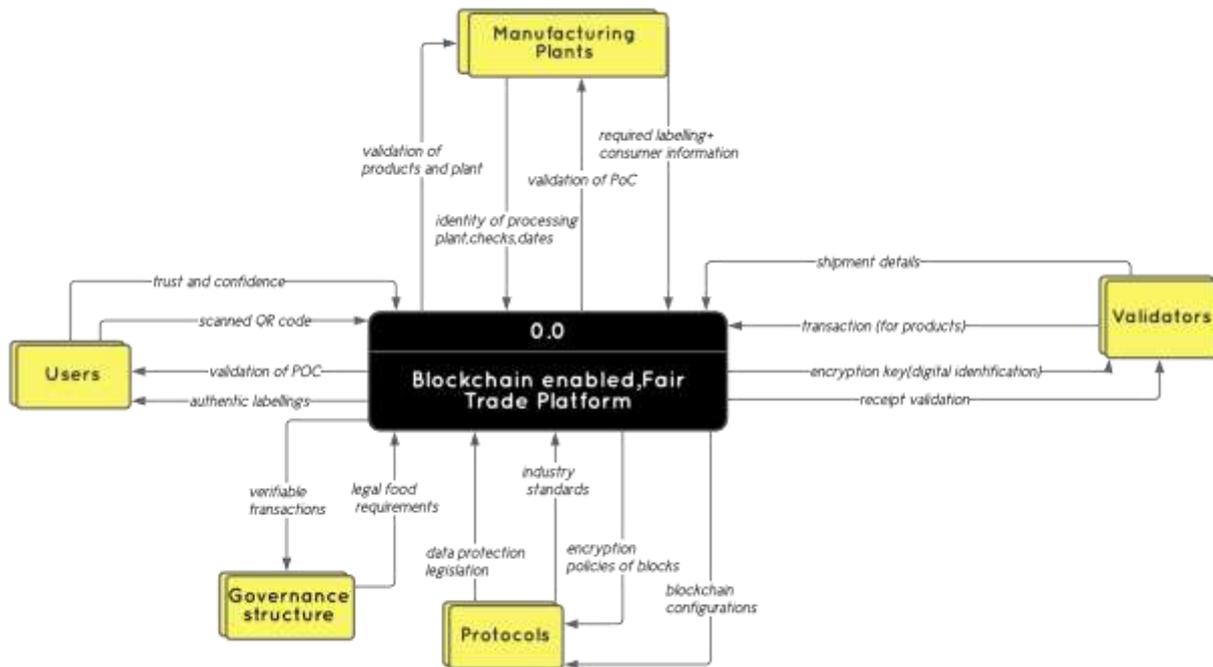
recommendations may be verified in a “trust-free” manner. While Choo *et al.* (2020) provided a recent and comprehensive set of managerial issues in blockchain research, workaround mechanisms that enforce the 3TIC attributes of blockchain platforms are gaps in the current research that need to be addressed. Such market analyses will highlight the multiple digital capabilities required to effectively conceive, design, implement, deploy, and evolve FT platforms in complex socio-technical environments. Demiray *et al.* (2021) suggested an entire stream of fruitful research in exploring new opportunities for entrepreneurs and businesses in collaborative or sharing platforms. The effects of institutional regulatory, cognitive, and normative dimensions on the perceptions of producers’ and consumers’ trust and engagement were investigated to understand their perspectives and what it took to maintain their continued participation in FT activities. In addition, trust enables engagement, which builds positive word of mouth (WOM) and satisfaction in the crowdfunding community. A blockchain-enabled FT ecosystem can be effectively designed to promote trust, positive WOM, and a good reputation among the producers, distributors, and consumers of products labeled “Fairtrade.”

There is considerable agreement among scholars and policymakers that digital innovation and entrepreneurship are engines of growth and societal development and platforms for establishing new business enterprises and possibly generating socially inclusive growth (Shaikh *et al.*, 2020). Digital innovation and enterprise research must examine the opportunities offered by digital platforms and how millennial entrepreneurs may exploit these to bring socioeconomic value to the marketplace.

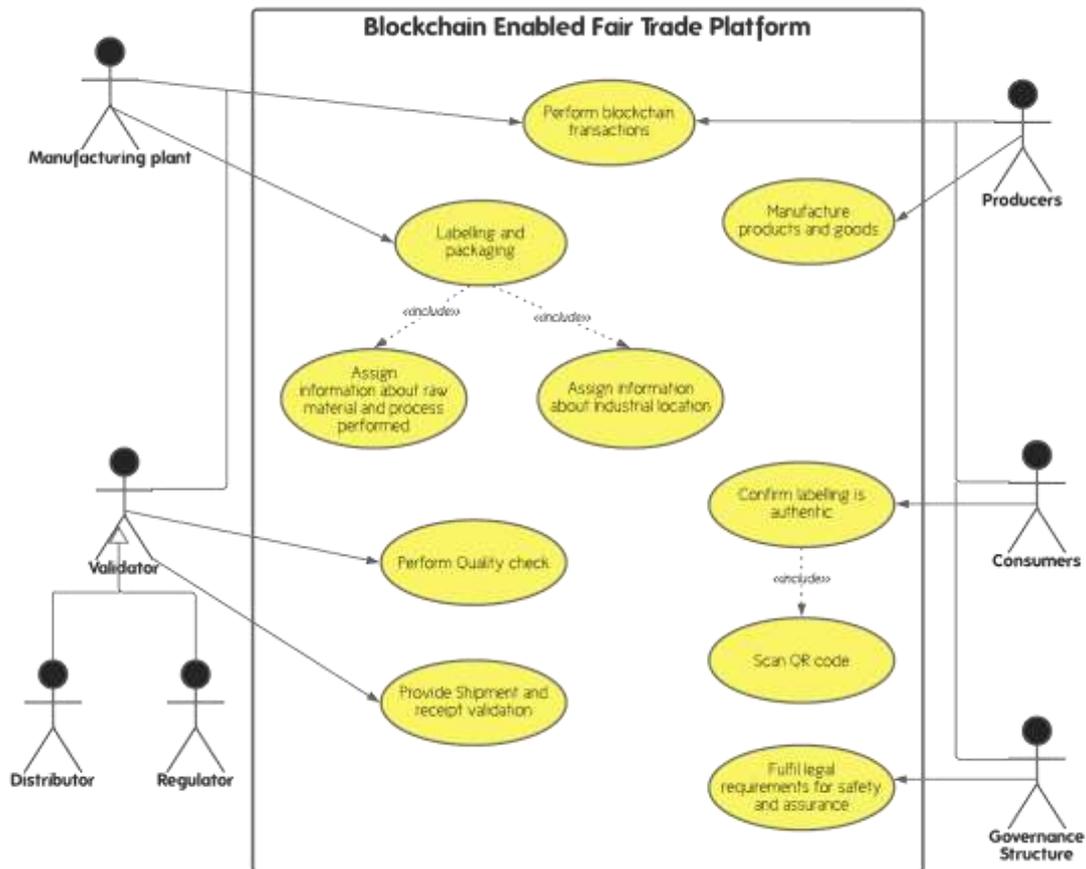
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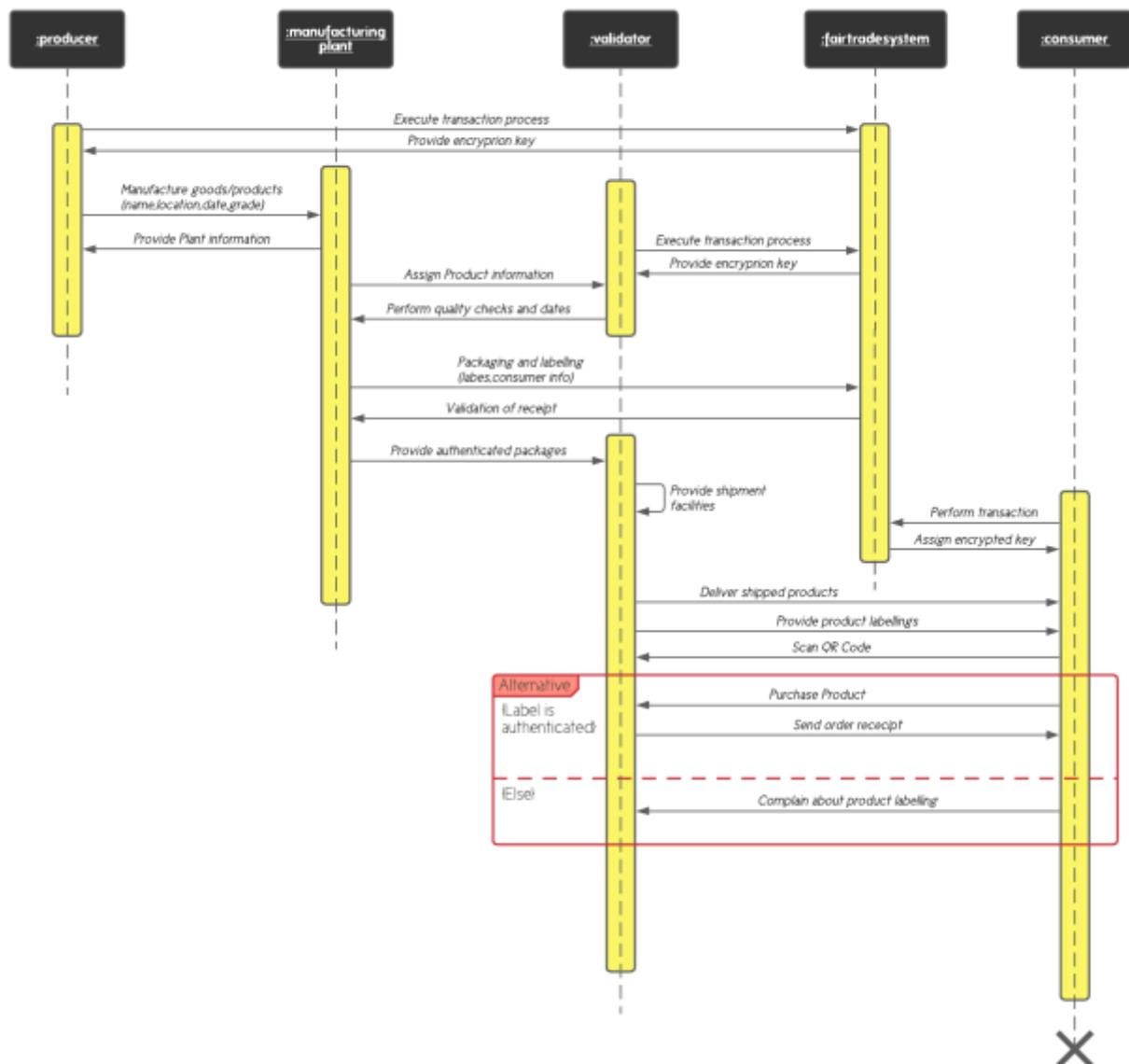
**APPENDIX A: Unified Modeling Language (UML 2.0) Context Diagram for Blockchain-enabled FT Platform.**



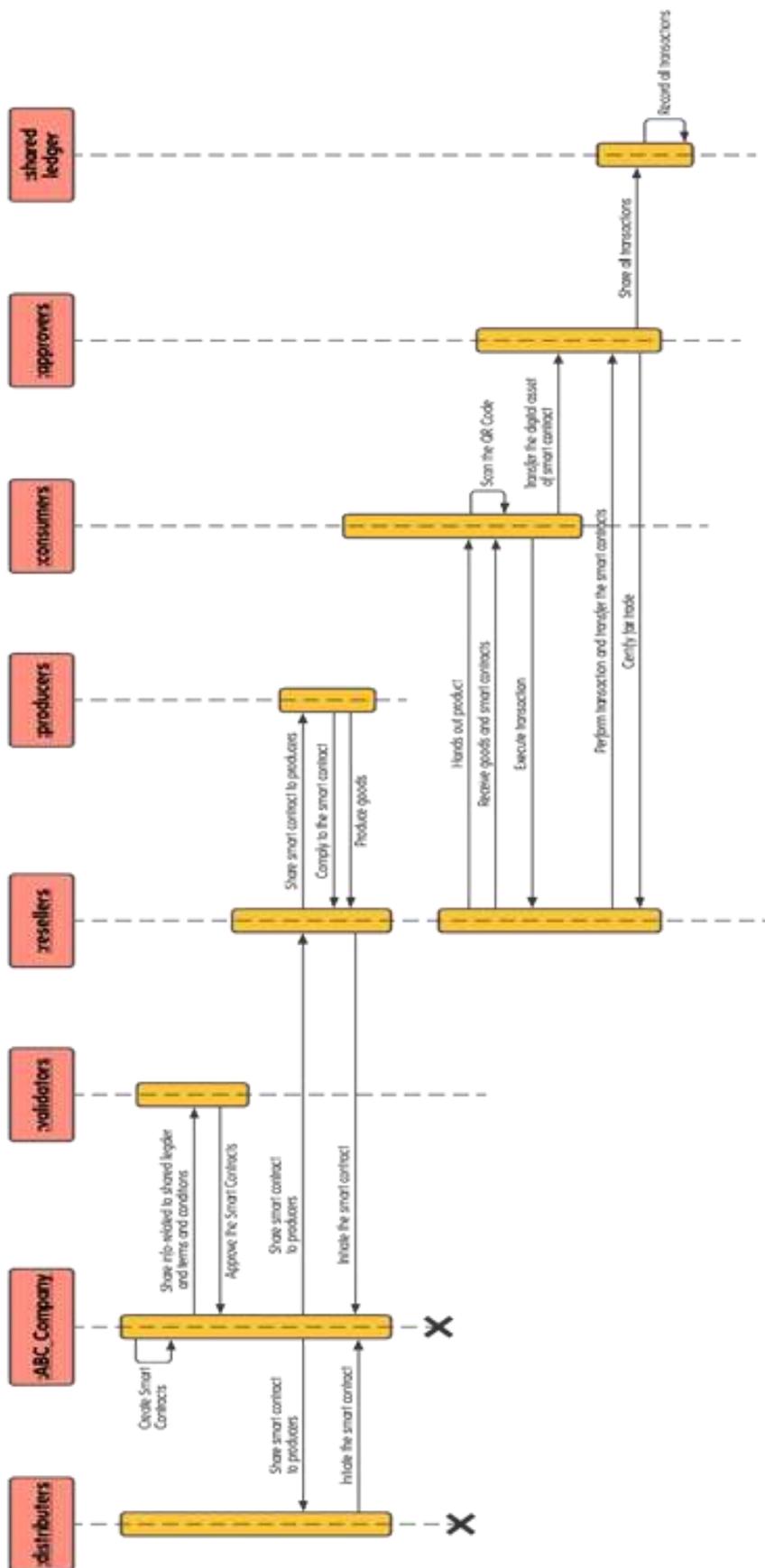
**APPENDIX B: UML v2.0 Use Case Diagram for 3TIC Fair-Trade.**



APPENDIX C: UML v2.0 Sequence Diagram for Typical Fair-Trade Transaction (Generic Solution)



APPENDIX D: UML v2.0 Sequence Diagram for Blockchain-Enabled Fair-Trade Solution



# Understanding the Sustainability Factors in Critical Information Systems for Disastrous Pandemics: A Knowledge-Based View

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## ABSTRACT

During the difficult time of coronavirus outbreaks, global environmental disasters, and financial turmoil, developing and deploying sustainable information systems is a crucial management task for ensuring the functionality of enterprise information processing and thus sustaining competitiveness. This study develops a set of criteria for sustainable information systems using the decision-making trial and evaluation laboratory (DEMATEL) method. By referring to the theory of knowledge-based view and sustainability, this study constructed a research framework in which the selection attributes reflect core knowledge elements of a sustainable information system. An empirical study was performed using the DEMATEL method with data collected from industry experts. The results conclude a cause and effect relationship of the knowledge factors influencing information system sustainability. The study discovered that the economical aspect is a causal factor of environmental aspect and social aspect for sustainability considerations. Furthermore, commercial IT solution knowledge, eco-design knowledge, and workplace safety and health knowledge are the most influential knowledge components for the economic, environmental, and social aspects of information system sustainability, respectively.

*Keywords:* Sustainability, information system, knowledge-based view, COVID-19, DEMATEL.

## INTRODUCTION

Organizations worldwide rely heavily on their information systems for effective operations towards sustainability (Braccini & Margherita, 2019). Information systems are developed with multiple roles in organizational operations (Tang, Tzeng & Wang, 1999). Enterprises employ managerial staff for decision-making using services provided by information systems. Sales and customer service staffs rely heavily on information systems for introducing and promoting products and services to corporate users. These various roles form a value network by participating and contributing to the value of enterprises. In an era of rapid product lifecycles with emergent information technologies such as big data analytics (Weng, 2020a), cloud computing (Wu, Lan & Lee, 2011), and smart mobile devices (Porter & Heppelmann, 2015; Weng, 2020b), information systems become even more critical for enterprises.

As the concept of sustainability emerges, the development and use of information systems are required to be aligned with the goal of corporate sustainability. However, determining the factors influencing the sustainability of information systems is complex, and research in this regard is scant so far. The goal of this paper is to fill this gap by proposing a systematic process to analyze critical factors which affect information system sustainability. Furthermore, since the development and maintenance of information systems are highly knowledge-intensive, knowledge plays an important role in sustainable information systems. This study utilizes a knowledge-based perspective as the theoretical background for extracting the critical factors in the decision process.

The paper begins with a review of the theoretical background of knowledge-based view and sustainability for information systems. Critical factors of sustainable information systems are collected from selected experts in Taiwan. Then it explains the DEMATEL method (Fontela & Gabus, 1976). Following that, the DEMATEL method is applied to analyze the data collected from the experts. Finally, the findings are presented along with the managerial implications of the study and suggestions for further research.

## THEORETICAL BACKGROUND

### A Knowledge-Based View of Information Systems

The knowledge-based view (KBV) is an outgrowth of resource-based thinking where the concept of resources is extended to include intangible assets and, specifically, knowledge-based resources. Some researchers see KBV as a useful extension of organizational learning to strategy and organization theory, an extension that is capable of informing research and providing new insights into organizational functioning (Eisenhardt & Santos, 2002; Grant, 1996). From the view of an organization, knowledge is absorbed and assimilated information for organizational operations, and intelligence is the knowledge gathered and organized for decision making (Porter & Millar, 1985).

Information systems help firms deal with uncertainty in business decisions and actions (Weng, 2020a). Nowadays, organizations are facing an even greater challenge in decision making than before, as the information to be processed is growing rapidly in volume, velocity, and variety (Johnson, Friend & Lee, 2017). Functions of information systems are cultivated through knowledge acquisition with organizational learning. The knowledge that firms acquire for pursuing and developing business strategy is an

important resource for the development of innovative information systems (Porter & Millar, 1985; Smith, McKeen & Singh, 2007).

The most fundamental knowledge for information system development is IT domain knowledge (Hasselbring, 2000; Shen et al., 2004). Participants of the system development lifecycle need to be knowledgeable in information technology to provide decisions on the benefits and risks of various IT solutions. However, IT domain knowledge alone cannot support sustainable information system integration. Enterprise information systems are built to facilitate business processes and regulations in the industry sector of the enterprises. There is complex business domain knowledge for each industry sector. Vendors, integrators, and consultants in the system development value network are expected to be more informative than the corporate users in business domains and provide consultancy to incorporate business knowledge in information systems (Shen et al., 2004).

In addition to IT domain knowledge and business domain knowledge, environment domain knowledge and social domain knowledge are becoming a prominent competence for information system development because of the increasing attention of corporate social responsibility (Choi & Hwang, 2015; Tseng et al., 2019) and corporate citizenship (Carroll, 1998; Di Domenico, Tracey & Haugh, 2009; Kruggel, Tiberius & Fabro, 2020). Green IT (Faucheux & Nicolai, 2011) and green IS (Anthony Jr, 2019) require substantial environmental domain knowledge. For sustainable information system integration, the knowledge spans resource-efficient methodologies (Anthony Jr, 2019; Fernández-Robin et al., 2019; Huang & Li, 2017; Yu et al., 2020), environment-friendly technologies (Day & Schoemaker, 2011; Mathews & Reinert, 2014), green supply chain operations (Hervani et al., 2005; Hwang et al., 2016; Sarkis et al., 2011), and application of innovative IT for green (Faucheux & Nicolai, 2011; Lokers et al., 2016; Weng, 2021b).

### **Sustainability in Information Systems**

Sustainability is measured with the triple bottom line (TBL): economical, environmental, and social performances (Braccini & Margherita, 2019). A firm's performances in these three dimensions need to be well balanced. Sustainability has become a critical objective in the entire life cycle of the design, development, and maintenance of corporate products and services (Chiu et al., 2016). However, the studies in the sustainability perspective are still rare for information systems.

Sustainability is often discussed together with corporate ethics. The two topics are tightly related to each other. While the concepts of ethics and sustainability have gained attention from corporations, the perceptions of firms on these concepts are widely divided (Chun, 2019; Searcy & Buslovich, 2014). Sustainability may imply different things to different organizations. This difference is intensified by the fact that different organizations use sustainability reports differently (Searcy & Buslovich, 2014). Also, views of corporate ethics may differ for different organizations. For example, American enterprises tend to emphasize different ethics measures with European enterprises (Chun, 2019). Previous research also pointed out that there are a large number of recognized drivers for the corporate sustainability concept that may affect corporations. The question of how to manage and balance the diversity of these drivers may cause challenges for corporate leaders. (Lozano, 2015).

Sustainability has become a critical measure in the entire life cycle of the design, development, and maintenance of corporate products and services (Chiu et al., 2016). Some measurement models for sustainability have been proposed for information system development, such as the GreenSoft model (Naumann et al., 2011; Venters et al., 2018). However, the studies in the sustainability perspective are still rare for information systems.

Moreover, sustainability is measured with three dimensions: economical, environmental, and social performances (Braccini & Margherita, 2019). A firm's performances in these three dimensions need to be well balanced. Thus in the development and adoption of information systems, factors influencing the performances in these three dimensions need to be considered simultaneously (Venters et al., 2018). These factors often interact and affect each other. Thus, evaluating and comparing the influences of these factors constitute a multiple-criteria decision-making task (Si et al., 2018; Tang et al., 1999; Wu et al., 2011)

## **RESEARCH METHOD**

### **Decision Criteria**

This study conducted literature review and industry expert interviews to collect the possible knowledge components for sustainable information systems. The related area encompasses the triple bottom line of sustainability (Braccini & Margherita, 2019).

### ***Knowledge Criteria of the Economical Aspect***

The economical aspect of information systems mainly reflects how information systems are developed and maintained in efficient and effective ways so that the systems can fulfill their intended purposes. To meet the economic considerations, knowledge of commercial IT solutions is essential for selecting the available commercial IT products and services that fit the budget and time constraints (Omoumi et al., 2021). Also, since, in most cases, information systems are digital automation of business processes, competence with business process knowledge is also mandatory (Baiyere, Salmela & Tapanainen, 2020). Furthermore, knowledge about the methodology and practices of software engineering is required for the entire lifecycle of system development. Finally, knowledge of system integration is indispensable to deal with the integration of various software and hardware components and subsystems.

### **Knowledge Criteria of the Environmental Aspects**

The environmental aspect of sustainable information systems focuses on enhancing the environmental benefit in the lifecycle of information system development. Green IT knowledge is required for adopting the methodologies of system development that minimize environmental impacts (Huang, 2009). Green business model knowledge helps the integration of information systems with environmental value creation (Sarkar, Qian & Peau, 2020). Green software engineering knowledge (Naumann et al., 2011; Venters et al., 2018) and eco-design knowledge (Brambila-Macias & Sakao, 2021; Mendoza et al., 2017) provide models and disciplines for environmental-friendly and eco-friendly information systems.

### **Knowledge Criteria of the Social Aspect**

The knowledge components of the social aspect are crucial to coping with the possible social impacts of information systems. Corporate citizenship knowledge is useful in guiding the development of information systems toward social responsibility (Akbari & McClelland, 2020). In the entire system development lifecycle, workplace safety and health knowledge are required for the safety and health of all stakeholders (Sorensen et al., 2018). Social, competitive knowledge (Rajković et al., 2021) and social marketing knowledge (Shawky et al., 2019) provide competitive intelligence and effective marketing campaigns through social activities and media; thus, these knowledge components can promote the social credence of information systems.

### **Decision Method**

The decision-making trial and evaluation laboratory (DEMATEL) method is an MCDM technique with applications in various areas (Lin et al., 2011; Wu et al., 2011). The DEMATEL method not only delivers a means to visualize the causal relationships among criteria through a cause-effect diagram but also evaluates the intensity to which the factors influence each other (Si et al., 2018). Thus, it is suitable for the purpose of this study.

The regular DEMATEL (Fontela & Gabus, 1976; Si et al., 2018) method contains four main steps: assessing the initial direct relation matrix by experts, normalizing the direct relation matrix, obtaining the total relation matrix, and producing a causal diagram (Si et al., 2018; Wu et al., 2011).

Let vector D and vector R, respectively, denote the sum of rows and the sum of columns from the total relation matrix obtained. The dimension (D+R), named prominence, shows how much importance the factor has. The dimension (D-R), named relation, divides factors into a cause group and an effect group. A factor is in the cause group if its (D-R) value is positive. A factor is in the effect group if its (D-R) value is negative (Fontela & Gabus, 1976; Wu et al., 2011).

The computing steps of the DEMATEL method can be further described as follows.

#### **1. The generation of the direct relation matrix**

The magnitude of the relationship between factors i and j can be represented by scales according to the following numerical levels: no influence = 0, low influence = 1, medium influence = 2, high influence = 3, and very high influence = 4.

An initial direct relation matrix Z is an nxn matrix obtained by averaging the pair-wise comparisons of experts in terms of impacts and directions between factors, in which  $z_{ij}$  is expressed as the degree to which the factor i affects the factor j, where  $1 \leq i, j \leq n$ .

$$Z = [z_{ij}]_{n \times n} \quad (1)$$

where all principal diagonal elements are equal to zero in Z.

#### **2. The normalization of the direct relation matrix**

The computation of the normalized direct relation matrix  $Y = [y_{ij}]$ , where  $0 \leq y_{ij} \leq 1$ , is performed through equations (2) and (3), in which all principal diagonal elements are equal to zero.

$$Y = f \times Z \quad (2)$$

Where

$$f = \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^n z_{ij}} \quad (3)$$

#### **3. The computation of the total relation matrix**

Once the normalized direct relation matrix Y is obtained, the total relation matrix T can be acquired by using equation (4), in which I denotes the nxn identity matrix and  $(I - Y)^{-1}$  is the inversion of the  $(I - Y)$  matrix.

$$T = Y \times (I - Y)^{-1} \quad (4)$$

#### **4. The exhibition of the causal diagram**

The sum of rows and the sum of columns are separately denoted as D and R in equations (5)-(7):

$$T = [t_{ij}]_{n \times n}, \quad i, j = 1, 2, \dots, n \quad (5)$$

$$D = \left[ \sum_{j=1}^n t_{ij} \right]_{n \times 1} \quad (6)$$

$$R = \left[ \sum_{i=1}^n t_{ij} \right]_{1 \times n} \quad (7)$$

In these equations, vector D and vector R are the sums of rows and the sum of columns from the total relation matrix T, respectively.

A cause and effect diagram is also called a causal diagram and is depicted using the values of D and R obtained from equations horizontal dimension (D + R) is obtained by adding R to D, and the vertical dimension (D - R) is obtained by subtracting R from D.

### Decision Process

Table 1 exhibits the decision framework.

Table 1: Knowledge factors for information system sustainability.

Aspect	Key Knowledge Component	
A1.Economical aspect	K01	Commercial IT solution knowledge
	K02	Business process knowledge
	K03	Software engineering knowledge
	K04	System integration knowledge
A2.Environmental aspect	K05	Green IT knowledge
	K06	Green business model knowledge
	K07	Green software engineering knowledge
	K08	Eco-design knowledge
A3.Social aspect	K09	Corporate citizenship knowledge
	K10	Workplace safety and health knowledge
	K11	Social, competitive knowledge
	K12	Social marketing knowledge

Source: This study.

The experts then assessed the influence of each aspect and factor in pairs by using equation (1) of the DEMATEL method described above. The final results were computed using equations (2)-(7). The results of the DEMATEL method were then utilized to evaluate the sustainability scores of three critical information systems for coping with the COVID-19 outbreaks. The meaning and significance of these results are elaborated as follows.

## RESULTS

Based on the knowledge elements stated above, as in Table 1, this research has further employed the DEMATEL method to capture the complex relationships among these factors. As the purpose of the study was to analyze the decision factors and their causal relationships in information system sustainability, a fourth aspect, A4 for information system, was added into the DEMATEL calculation of the relationships among aspects.

The collected pairwise comparison results have been obtained (the comparison mechanism has been described at step 1 of the DEMATEL method), and that the preliminary average direct relation matrix is shown in Tables 2a-2d. Based on the direct relation matrix, these numbers are normalized continuously into the normalized relation matrix (calculated by equations (2) and (3)). The total relation matrix is then obtained by using equation (4).

### The Initial Direct Relation Matrices

The collected pairwise comparison results were obtained (the comparison mechanism has been described at step 1 of the DEMATEL method), and that the preliminary average direct relation matrix is shown in Tables 2a-2d.

Table 2a: Direct relation matrix of the four aspects.

	A1	A2	A3	A4
A1	0.000	2.286	2.571	2.714
A2	2.143	0.000	3.714	2.000
A3	1.857	3.286	0.000	2.000
A4	2.429	1.429	1.429	0.000

Source: This study.

Table 2b: Direct relation matrix of economical aspect.

	K01	K02	K03	K04
K01	0.000	1.714	2.857	2.714
K02	1.286	0.000	1.857	1.857
K03	2.857	2.000	0.000	2.857
K04	2.714	1.429	2.714	0.000

Source: This study.

Table 2c: Direct relation matrix of environmental aspect.

	K05	K06	K07	K08
K05	0.000	1.571	2.714	1.857
K06	1.571	0.000	2.143	3.000
K07	3.143	1.571	0.000	2.429
K08	3.000	3.143	3.286	0.000

Source: This study.

Table 2d: Direct relation matrix of the social aspect.

	K09	K10	K11	K12
K09	0.000	3.429	1.857	2.000
K10	3.714	0.000	2.429	3.000
K11	2.143	1.714	0.000	3.143
K12	2.714	2.286	3.571	0.000

Source: This study.

### **The Normalized Direct Relation Matrices**

The direct relation matrices were normalized continuously into the normalized relation matrices by using equations (2) and (3). The results are shown in Tables 3a-3d.

Table 3a: Normalized direct relation matrix of the four aspects.

	A1	A2	A3	A4
A1	0.000	0.291	0.327	0.345
A2	0.273	0.000	0.473	0.255
A3	0.236	0.418	0.000	0.255
A4	0.309	0.182	0.182	0.000

Source: This study.

Table 3b: Normalized direct relation matrix of economical aspect.

	K01	K02	K03	K04
K01	0.000	0.222	0.370	0.352
K02	0.167	0.000	0.241	0.241
K03	0.370	0.259	0.000	0.370
K04	0.352	0.185	0.352	0.000

Source: This study.

Table 3c: Normalized direct relation matrix of environmental aspect.

	K05	K06	K07	K08
K05	0.000	0.167	0.288	0.197
K06	0.167	0.000	0.227	0.318
K07	0.333	0.167	0.000	0.258
K08	0.318	0.333	0.348	0.000

Source: This study.

Table 3d: Normalized direct relation matrix of the social aspect.

	K09	K10	K11	K12
K09	0.000	0.375	0.203	0.219
K10	0.406	0.000	0.266	0.328
K11	0.234	0.187	0.000	0.344
K12	0.297	0.250	0.391	0.000

Source: This study.

### The Total Relation Matrices

After the normalized relation matrices were obtained, the total relation matrices were then computed by using equation (4). The results are shown in Tables 4a-4d.

Table 4a: Total relation matrix of the four aspects.

	A1	A2	A3	A4
A1	1.788	2.163	2.317	2.103
A2	2.080	2.040	2.505	2.130
A3	1.934	2.195	2.034	1.999
A4	1.592	1.621	1.724	1.401

Source: This study.

Table 4b: Total relation matrix of economical aspect.

	K01	K02	K03	K04
K01	1.922	1.662	2.283	2.274
K02	1.540	1.077	1.652	1.654
K03	2.263	1.740	2.087	2.358
K04	2.110	1.582	2.195	1.936

Source: This study.

Table 4c: Total relation matrix of environmental aspect.

	K05	K06	K07	K08
K05	0.667	0.690	0.909	0.782
K06	0.879	0.614	0.944	0.930
K07	1.004	0.762	0.775	0.898
K08	1.173	1.023	1.222	0.872

Source: This study.

Table 4d: Total relation matrix of the social aspect.

	K09	K10	K11	K12
K09	1.551	1.675	1.612	1.662
K10	2.111	1.646	1.907	1.985
K11	1.658	1.486	1.384	1.670
K12	1.933	1.739	1.886	1.642

Source: This study.

### The Cause and Effect Relations

After the total relation matrices were obtained by using equation (4), equations (5)-(7) were utilized to compute the cause and effect relations. The results are shown in Table 5.

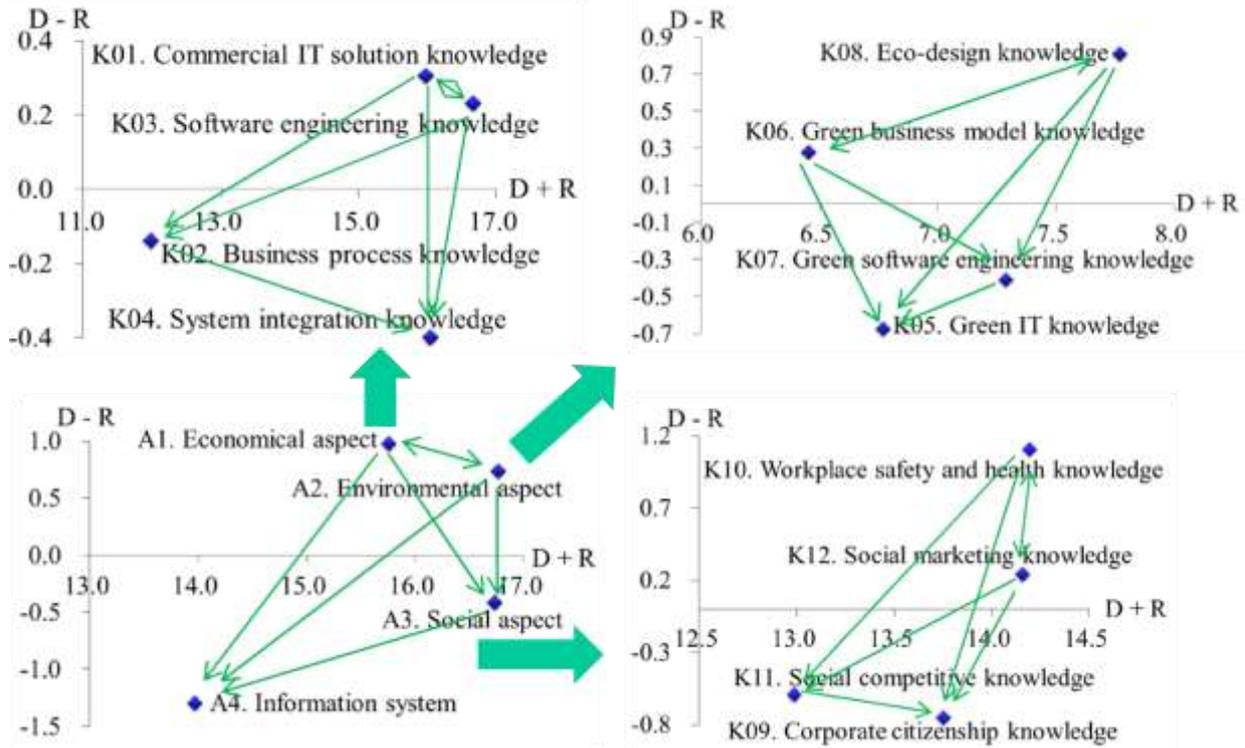
Table 5: Prominence and relation values.

Factor	D	R	D + R	D - R
A1	8.371	7.393	15.764	0.978
A2	8.755	8.019	16.773	0.736
A3	8.162	8.580	16.742	-0.418
A4	6.337	7.633	13.971	-1.296
K01	8.141	7.835	15.976	0.306
K02	5.922	6.061	11.983	-0.139
K03	8.448	8.216	16.664	0.232
K04	7.822	8.221	16.044	-0.399
K05	3.047	3.724	6.771	-0.676
K06	3.367	3.089	6.455	0.278
K07	3.439	3.850	7.290	-0.411
K08	4.290	3.481	7.771	0.810
K09	6.500	7.253	13.753	-0.754
K10	7.649	6.546	14.195	1.104
K11	6.198	6.789	12.988	-0.591
K12	7.200	6.959	14.159	0.241

Source: This study.

**The Causal Diagram**

Finally, the causal diagram is produced and displayed in Figure 1 by mapping the dataset of (D + R, D-R) in Tables 5. Based on the data set shown in Table 5, we obtained the bottom left panel of Figure 1, which demonstrates the causal relationships among the four aspects. The other three panels of Figure 1 demonstrate the causal relationships among the components within the aspects of economical (upper left panel), environmental (upper right panel), and social (lower right panel), respectively.



Source: This study.

Figure 1: Causal diagram for the sustainability in information systems.

**The Sustainability scoring of Critical Information Systems**

Based on the knowledge factors analyzed above as in Table 5, this study then further invited the experts to evaluate three critical information systems deployed for the COVID-19 pandemic. The scoring is scaled from 1 (for low score) to 5 (for high score)—the average scores are computed in Table 6.

Table 6: Sustainability rating of critical information systems.

Knowledge factor		Normalized D + R as weight	Information system 01		Information system 02		Information system 03	
			Public health status and infection monitoring		Logistics and distribution of critical healthcare materials		Remote medical and healthcare services	
			Average score	Weighted score	Average score	Weighted score	Average score	Weighted score
K01	Commercial IT solution knowledge	0.084	3.429	0.289	3.714	0.313	3.286	0.277
K02	Business process knowledge	0.063	2.571	0.162	3.286	0.208	2.857	0.181
K03	Software engineering knowledge	0.088	3.286	0.289	3.429	0.301	2.714	0.238
K04	System integration knowledge	0.085	2.714	0.230	2.857	0.242	3.000	0.254
K05	Green IT knowledge	0.081	3.143	0.256	2.857	0.233	3.286	0.268
K06	Green business model knowledge	0.078	2.857	0.222	3.000	0.233	3.286	0.255
K07	Green software engineering knowledge	0.088	2.714	0.238	2.571	0.226	2.857	0.251
K08	Eco-design knowledge	0.094	2.571	0.240	2.571	0.240	3.000	0.281

K09	Corporate citizenship knowledge	0.085	2.143	0.182	2.571	0.218	3.571	0.303
K10	Workplace safety and health knowledge	0.088	2.286	0.200	2.286	0.200	3.571	0.313
K11	Social competitive knowledge	0.080	2.000	0.160	2.000	0.160	3.143	0.252
K12	Social marketing knowledge	0.087	2.143	0.187	2.429	0.212	3.286	0.287
	Total score	1.000		2.655		2.786		3.158

Source: This study.

Table 6 shows that the sustainability scores of all the three information systems are 2.655, 2.786, and 3.158, respectively, which are medium by the scale of 1 to 5. The score in each knowledge factor can be used as a reference for further improvement of the sustainability in these information systems.

## DISCUSSION

By examining Figure 1 and Table 5, each factor can be analyzed, and its impact on the overall sustainability discussed. Hence, the critical knowledge components influencing the sustainability of information systems can be determined, as is discussed next.

### The Cause Group and the Effect Group

The results shown in the causal diagrams in Figure 1 have discovered the cause and effect relationships of these core knowledge elements in driving information systems toward sustainability. It is observed that, by looking at these causal diagrams, the factors can be divided into a causal and an effective group. The cause group includes factors with positive ( $D - R$ ) values, while the effect group includes factors with negative ( $D - R$ ) values. Since the causal factors have a net impact on the overall framework, their performance can greatly influence the overall goal. Thus, it is generally accepted that the factors in the cause group should be closely monitored. Conversely, the factors in the effect group tend to be easily affected by others, which makes them unsuitable as critical impact factors.

Thus, the cause group contains economical aspect (A1), environmental aspect (A2), commercial IT solution knowledge (K01), software engineering knowledge (K03), eco-design knowledge (K08), green business model knowledge (K06), workplace safety, and health knowledge (K10), and social marketing knowledge (K12).

The effect group includes social aspect (A3), information system (A4), business process knowledge (K02), system integration knowledge (K04), green software engineering knowledge (K07), green IT knowledge (K05), competitive social knowledge (K11), and corporate citizenship knowledge (K09).

Therefore, the cause and effect structure in Figure 1 implies that among the knowledge components, K01, K03, K06, K08, K10, and K12 are the main knowledge components in leading information systems to move toward sustainability. Subsequently, knowledge components K02, K04, K05, K07, K09, and K11 are not causal but affected. Thus, they are derived and influenced by the other knowledge components for determining the sustainability of information systems.

### Analysis of the Aspects

As the results exhibited in Table 5 and the bottom left panel of Figure 1 demonstrate, among the four aspects, the economical aspect (A1) has the highest ( $D - R$ ) value, which means that it has a greater impact on the entire framework than it receives from the other aspects. However, the environmental aspect (A2) and social aspect (A3) are the two factors with higher ( $D + R$ ) values. Thus they are of high importance in the framework.

The results also reveal that the environmental aspect (A2) is the most important causal factor (with the highest  $D$  value) among the three bottom lines, and generates a competitive impact (positive  $D - R$ ), thus making it the most significant aspect of knowledge to the sustainability of information systems. These guidelines of improvement direction will lead information systems toward a more sustainable level.

These results imply that while knowledge components in the environmental aspect and social aspect are important regarding information system sustainability, they are nevertheless influenced by knowledge components in the economical aspect. Therefore, the utilization of environmental and social domain knowledge in information system development is substantially affected by economical domain knowledge.

### Analysis of Knowledge Components in the Economical Aspect

The results exhibited in Table 5 and the upper left panel of Figure 1 show that, among the knowledge components in the economical aspect, commercial IT solution knowledge (K01) and software engineering knowledge (K03) have positive ( $D - R$ ) values and thus are causal factors.

The commercial IT solutions for contemporary information systems include many turn-key products which already encapsulate business processes (K02) and can facilitate system integration (K04). The system analysis and design phase in software engineering also perform business process analysis. System integration needs to be guided and planned in the subsystem development of software engineering.

Thus, with respect to the economical aspect, commercial IT solution knowledge is the most influential component and should be enhanced first, followed by software engineering knowledge, as shown in Figure 1. These knowledge components expedite successful information system development and reduce the waste of resources and time; thus, they help promote the sustainability of information systems.

#### **Analysis of Knowledge Components in the Environmental Aspect**

As the results exhibited in Table 5 and the upper right panel of Figure 1 indicate, among the knowledge components in the environmental aspect, eco-design knowledge (K08) and green business model knowledge (K06) have positive (D – R) values and thus are causal factors.

Figure 1 also shows that eco-design knowledge is the most important component with the highest (D + R) value. It has an influence on green business model knowledge (K06), green software engineering knowledge (K07), and green IT knowledge (K05). This indicates that eco-design knowledge is the stimulating knowledge component of the other environmental domain knowledge and should be improved and promoted first, followed by green business model knowledge, as shown in Figure 1. Eco-design knowledge is tacitly embedded in many green business practices and is essential for the environmental-friendliness of the system development lifecycle.

#### **Analysis of Knowledge Components in the Social Aspect**

The results exhibited in Table 5 and the lower right panel of Figure 1 show that, among the knowledge components in the social aspect, workplace safety and health knowledge (K10) and social marketing knowledge (K12) have positive (D – R) values and thus are causal factors.

Figure 1 also shows that workplace safety and health knowledge is the most prominent component with the highest (D + R) value. It has an influence on social marketing knowledge (K12), competitive social knowledge (K11), and corporate citizenship knowledge (K09). This indicates that workplace safety and health knowledge are the causal knowledge components of the other social domain knowledge and should be improved and promoted first, followed by social marketing knowledge, as shown in Figure 1. Particularly, facing the disastrous COVID-19 outbreaks nowadays, workplace safety and health knowledge are indispensable and inevitable for the social sustainability of the system development lifecycle. Its profound impact on the other social domain knowledge and the entire decision framework of sustainable information systems will continue to extend.

### **CONCLUSIONS**

In conclusion, knowledge factors are essential to the success of engineering and management of information systems. However, past studies have not provided sufficient analysis of the interaction relation among them. Moreover, information system sustainability has emerged in recent years, and hence its influencing factors remain unclear. Through the analysis performed, this study has made contributions in the following perspectives: (1) linking knowledge-based view with sustainability; (2) defining the critical knowledge elements for information system sustainability; (3) investigating the interrelationship of these critical knowledge elements; (4) demonstrating DEMATEL method as an effective multiple criteria decision-making tool in supporting the exploration of the cause and effect relationship in a complex decision system; (5) analyzing critical impacts based on the generated causal diagram and providing improvement strategies accordingly.

This study analyzes factors affecting the sustainability of information systems from a knowledge-based perspective. Although knowledge is a critical intangible resource in the development of information systems, other factors are worth further attention (Weng, 2021a). Moreover, the analyzing process in this study can be applied to specialized systems such as medical information systems and smart healthcare-related systems (Weng, 2021b). Further investigations into these topics are recommended.

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## **A Case Study of the Application of Digital Technology in the Fast-Food-Breakfast Industry to Optimize Consumer Demand**

*(Work in Progress)*

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### **ABSTRACT**

According to research in many medical journals, breakfast is extremely important to human health. A nutritious breakfast can make people energetic and improve the efficiency of study and work. People in different countries and regions have a unique breakfast culture. In Taiwan, the breakfast/brunch-based industry is one of the franchise channels that has always been the fastest and easiest way for Taiwanese self-employed people to start a business. Some brands even have gone international and started to expand their business. This research study used G.C. Group as the research object and investigated the use of digital tools by franchisees through case combing and in-depth interviews with key stakeholders. The research analysis the digital implementation to assist the franchise headquarters on how to use digital technology to optimize franchisees, consumer services, and brand value enhancement. The research results find possible business models at the emergence stage, and maximizing value exchange and business opportunities through the interaction of all important stakeholders will be the direction of future research.

*Keywords:* Fast-food breakfast industry, franchise headquarters, franchisee, IM Chatbots

### **INTRODUCTION**

#### **An Overview of the Chinese Fast Food Breakfast Industry and Research**

Omelet, radish cake, baked egg toast, milk tea, which are commonly found in Chinese breakfast, are sold in many small chain stores that people are familiar with. Most of these store operations exist in the form of participating in franchising. The franchise headquarters assists franchisees in site selection, store management, education, and training, customized the cooking menu and other counseling measures to provide entrepreneurs with low entry barriers and brand-sharing market competitive strategy advantages, becoming a unique business type in Taiwan. According to statistics from the Taiwan Franchise Promotion Association, Taiwan currently has more than 2,000 chain brands with the highest density in the world. The main reason is that more than 90% of the domestic industrial structure is SMEs, and the people are brave to innovate and start businesses and are keen on themselves. Therefore, becoming a boss is the fastest and easiest way to start a business through a franchise alliance.

The subject of this research is the G. C. Group. Chairman opened the first breakfast restaurant in 1988 and started franchising in 1990. There are now more than 300 restaurants. The second-generation successor, the CEO, had studied abroad and received an IT degree. After returning to China to study business management, he began to actively promote the internal transformation of the group, hoping to use digital technology and artificial intelligence technology to optimize customer service experience and operational management performance.

#### **Research case background description**

The G.C. Group was established in 1998, and the food is served delicious in many people's memories. When the CEO took over the headquarters business in 2016, he first adjusted the brand positioning and menu and then introduced free franchise funds, deposits, and store upgrade plans for franchisees. On the other hand, in order to create a new experience in the breakfast culture, the CEO began to develop a new brand, "MOLU TOAST," that combines local ingredients to attract international tourists to Taiwan's must-eat breakfast and popular Internet celebrity stores. The main purpose is to provide franchisees with options to maintain the traditional taste of the G.C. Brand or choose to switch to the "MOLU TOAST" brand and formulate a new market management strategy on the original location.

This case study takes the G.C. Group as an example. The important evolution of the company is as follows—

- 2004 The franchise chain headquarters established a factory that complies with CAS standard operations.
- 2005 Leading the industry to launch all-material health-preserving vegetable and fruit materials.
- 2006 Set up a logistics center for freezing point dessert materials.
- 2012 Established the first in Taiwan to use heat-resistant, non-precipitating plasticizer for PP coating packaging materials.

- 2014 Exported technology transfer training and shop opening counseling overseas.
- 2016 Introduced the fourth generation of new store design.
- 2017 Evaluate the development of new brands.

In the past, the G. C. Group focused on improving product development and hygiene quality as its main business mission. In recent years, it has shifted to making strategic corrections based on consumers' health orientation and consumer experience. The CEO believes that a bolder transformation is needed at this time, including the use of digital technology and artificial intelligence technology to improve operation management, product optimization, franchise customization services, consumer experience, and the provision of multiple payment tools.

## PROBLEM STATEMENT

### **Demand interview and survey of franchise headquarters**

At present, the management of the G. C. Group's brand only provides franchise strategies. According to the results of the interview with the CEO, the research found that if you want to introduce the layout of digital technology and AI applications, you should give priority to solving the pain points of "franchise owners" and "consumers." Digitization is the starting point to enter the field of AI. Therefore, the research found that franchise headquarters, in collaboration to conduct related telephone interviews with the franchisees. The results show that more than 20% of the stores use "Line" (instant messenger, IM software) to provide breakfast menus, 10% use Facebook fan pages to operate the community, and more than 60% of them apply for business registration with the local government.

### **Franchisees use digital tools to investigate and summarize**

After continuing to interview the supervisors in each district, summarize the behaviors and cognitions of the following franchisees using digital tools, including:

- (1) Almost all franchisees use Line for their daily contact with their families or work (posting photos).
- (2) More than 80% of the franchisees are local mothers. They don't know how to use technology to increase business, but they also say that they will not reject them. If you want them to use a mobile phone or a tablet device, the operation interface must not be too complicated, and the point where you need to click must not be too small.
- (3) There are a small number of young couples or first-time entrepreneurs in the franchise, which have a relatively high degree of digital acceptance, and a high proportion of interaction with consumers using social marketing tools such as Line, Facebook, and IG.

## RESEARCH DESIGN AND PLANNING

### **Use touchpoints in the customer journey to build a good impression of the company or product**

Most consumer behaviors are not carried out directly. They will use a lot of information to repeatedly confirm their needs, research alternative products, and finally find the expected solution or product. This is a decision-making process of continuous thinking and evaluation. In other words, the customer journey refers to the process by which consumers interact with a brand or company's products or services. This perspective essentially considers the integrity of the customer experience, combining the customer's cognitive, emotional, sensory, social, and spiritual responses to all interactions with the company (Bolton et al., 2014). In business practice, the customer experience is also broadly defined in all aspects of the company's products, such as the quality of customer service, as well as advertising, packaging, product and service functions, ease of use, and reliability. The development of all interactions can be seen from the overall perspective of pre-purchase, in-purchase, and post-purchase. These places that may be in contact with the brand are called "touchpoints" (Homburg et al., 2015). The consumer's perception of the brand actually depends on his mood changes and flow in this customer journey, through the touchpoints collected by consumers in multiple stages of the decision-making process or purchase journey, the so-called "building experience" (Pucinelli et al., 2009).

### **Paying attention to the consumer experience is essential for companies**

Creating a good consumer experience is an important goal of modern managers, and all companies must create unforgettable activities for consumers. "Future economic growth lies in the value of experiences and transformations--good and services are no longer enough." (Pine and Gilmore, 1999). Due to the adoption of technology, consumers can easily interact with the company's multiple touchpoints through various channels and media. With the continuous increase in the number and complexity of touchpoints, the customer journey has become more and more complex; in addition to having to pay attention to the consumer experience at all times, managers have also become the new normal in the face of omni-channel management (Brynjolfsson, Hu & Rahman 2013).

Given the relatively nascent state of the customer experience literature, empirical work directly related to customer experience and customer journey is limited. Therefore, this research will conduct a case study through the fast breakfast industry--observe the franchise headquarters introducing digital tools to improve the effectiveness and key insights of customer experience, customer journey, and customer experience management practices, and compare the historical perspective of customer experience in related marketing, as a reference and research topic for follow-up development of the industry.

### Use the customer journey map for this case study

In order to solve the problem of G.C. Group, the research made suggestions to the chairman and CEO and assisted the franchise headquarters, franchisees, and consumers to provide service optimization suggestions according to each touchpoint of the customer journey. Next, this survey began to interview representatives of stakeholders in the business ecosystem, inspected the existing information system of the franchise headquarters, and summarized the digital ecological development needs of consumers, franchisees, and franchise headquarters, as shown in the figure.



Source: This study.

Figure 1: Key points of interviews with key stakeholders

Aiming at the strategic layout of G.C. Group's digital development, the research proposes two application scenarios, B2B (franchise headquarters to franchisees) and B2B2C (franchise headquarters to franchisees to consumers), and separately develops suitable digital technology and artificial intelligence technology service plans.

## RESULTS OBSERVATION AND DISCUSSION

### Using IM Chatbots should be easy to use for franchisees

After determining the dual-brand positioning of GC Group, the author and the franchise headquarters jointly investigated the franchisees' behavior and perception of using digital tools. The results show that almost all franchisees have the basic operating capabilities of digital communication software (such as LINE, Facebook, etc.), and they have a positive and open attitude towards applying digital technology to increase income and improve consumer services. They were faced with the needs of consumers with high repetitive query content, multiple marketing activities, and the creation of interactive scenes. The AI-based Chatbots program that simulates real human conversations through Chatbots should be the most suitable tool at present. Regarding whether users will resist the use of new tools, the research found that most of the franchisees of GC Group have used Line in the past, so it should be easy to import IM Chatbots API interface such as Line or Facebook through simple linearization process settings and provide franchisees an easy use start.

### IM Chatbots can improve the management of franchise headquarters

In addition, IM Chatbots can automatically reply at any time, collect basic customer information, and establish automated marketing and sales processes. The franchise headquarters should find personnel management costs reduced partially, the frequency of marketing activities can be increased, common product shopping guides are provided that cascade multiple payments to attract consumer participation and improve satisfaction. If the IM Chatbots can be combined with CRM analysis, it will be able to further precision marketing and open up diversified sales opportunities. For the service purposes of the B2B and B2B2C business models, the research recommends the development of two IM Chatbots, one of which is the information delivery and two-way communication between the franchise headquarters and the franchisee, the notification reminder of raw material inventory replenishment, remote service and support assistance; the other Chatbots is mainly used as direct and indirect business potential consumers and members. Before adopting digital tools, the research suggests that the franchise headquarters must digitally integrate or return existing consumer data (i.e., establish a membership database), which will help launch G.C. Group brand joint activities, single-brand or regional marketing activities. Use the membership database list to guide consumers to franchisees for consumption and introduce new consumer groups; franchisees also promote preferential information in stores, encourage consumers to join the brand community, and then provide continuous bonus rewards through marketing incentives to increase membership conversion rate and stickiness.

## CONCLUSION

The fast-food breakfast industry belongs to the catering service industry, and it is also one of the service formats that people's livelihood has the most daily exposure to. The introduction of artificial intelligence technology sounds like a long way off. In fact, now that data is widely used, artificial intelligence technology and perceptual environment have been connected to various digital devices in our lives. Once consumers feel the distinctive service, the brand will be valuable. In other words, if

artificial intelligence can be used to understand consumer behaviors, grasp service trends, and complete online and offline omni-channel integration, it will help to enhance franchise headquarters, franchisees, and consumers' recognition of brand value. Next, how to use digital technology and artificial intelligence to become a profit-maximizing and co-creation business model, and to maximize value exchange and business opportunities through the interaction of all important stakeholders, will be a future research direction.

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omni-channel integration, it will help to enhance franchise headquarters, franchisees, and consumers' recognition of brand value. Next, how to use digital technology and artificial intelligence to become a profit-maximizing and co-creation business model, and to maximize value exchange and business opportunities through the interaction of all important stakeholders, will be a future research direction.

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## An Empirical Study on Consumption Intention of Virtual Tour Streaming

(Work in Progress)

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### ABSTRACT

This study employs the social interaction motivation of the audience to explore the social capital dual-model relationship generated by the audience of “Virtual Tour Streaming,” a term that describes virtual tour streaming’s nascent digital economy. This is situated in a virtual tour streaming platform to ascertain how it influences the intention of the audience and to use “Swift Guanxi” as the interaction variable to actual intention behavior. This is done to understand the contributions of virtual tour streaming adoption in a direct dial platform of different audience levels and their consumption behavior. The remaining sections discuss the theoretical and practical implications of the study.

*Keywords:* Consumption intention, bonding social capital, bridging social capital, vertical social motivation, horizontal social motivation, swift guanxi

### INTRODUCTION

#### Background and Motivation of the Project

With the booming development of the internet, people are more focused on time-saving. Electronic commerce has greatly changed the shopping habits of customers, devoted largely to the merchandise on the internet instead of going to physical stores. The so-called electronic commerce of virtual tour streaming means to change the medium and to maintain the relationship with information and communication media. Also, it implies the establishment of the business activity between a streamer and a different level of audience (Lee *et al.*, 2007). However, with more and more virtual tour streaming platforms being used, the information of a product posted on the Internet is difficult to be totally accepted by the audience. Thus, most people seek advice from the Internet as virtual tour streaming platform has become the source of objective information for purchasing decisions.

Virtual tour streaming platforms such as YouTube and Facebook were ranked as part of the top three in 2017. This is attributed to the information it provides on products which consequently leads to the popularity of virtual tour streaming platforms. It has become conspicuous and certain that due to the anonymity of the internet space, there is a barrier that creates mistrust among virtual tour streaming audiences. Thus, the message and information contained in virtual tour streaming platforms are shrouded with uncertainty and unpredictable risk, which include origins of a product, risk of logistics and cash flow, and the integrity of the buyer and seller. This ultimately requires the need to pay more attention to decision-making under this volatile and uncertain situation. This situation is accentuated by scholars (e.g., Cho *et al.*, 2006; Ou *et al.*, 2014; Pavlou *et al.*, 2007) who maintain that it would affect the consumption intention of potential consumers. With the consumption pattern changing, most people deem the internet as a medium to trade, and the rate of shopping via the internet has ballooned incredibly. When the audience of the platform uses virtual tour streaming, the cause of consumption might depend on the familiarity level with the seller or the different views expressed by the audience. This is because they have considerable knowledge of this product or could refer to the information given by the audience to change the intention policy themselves. Interestingly, virtual tour streaming platforms do not only make the audiences establish their own image but also share the message with others or join the platform to build relationships among each other. The platform also sustains the interaction of audiences as well as keeps their relationship, and extend their social cycle (Ou *et al.*, 2014; Phua *et al.*, 2017). The interaction in this regard means the relationship intensity between the audience of virtual tour streaming as well as the medium of message and resource. Equally important is the time they spend and the frequency of communication in the virtual tour streaming platform. Virtual tour streaming platforms can create valuable messages and resource for the audience, initiate new interpersonal relations, and maintain original relationships (Chou & Hsu, 2016; Ou *et al.*, 2014).

Social capital is a multi-faceted concept that covers the interaction that ensues among the audience in the virtual tour streaming platforms. The platform can be created, maintained, and enforced by the function of communication and interaction. It is not a misnomer to aver that social capital is evident in the virtual tour streaming space (Choi & Lim, 2016). This becomes materialized if the behavior engendered after the interaction between the audience creates an outstanding communication quality, and the information acquired would promote positive feedback such as consumption intention. Although there is uncertainty in the online

shopping market, however, virtual tour streaming platforms provide pieces of information that generate trust and mutual understanding among the audience. This encapsulates the concept of social capital. Capital in this context means enough streaming, information, and resource, which can eliminate the uncertainty of online shopping and information and afford the audience to have the right to decision making, which would affect consumption intention.

Therefore, this study employs bonding social capital and bridging social capital as important factors of consumption intention, which is advocated by Sheer and Rice (2017). Though the two concepts mean the rate of estrangement, however, bonding social capital encapsulates familiarity or acquaintance while bridging social capital represents the rate of unfamiliarity in a relationship. This necessitates social capital as a bridge to restore normalcy. When the motivation of virtual tour streaming usage is different, social capital will equally have different results (Salehan *et al.*, 2017; Sheer & Rice, 2017). However, to investigate the motivations of the audience requires the need to ascertain the level of information about the product that one needs to understand. This could be achieved through interaction with the audience.

Finally, the study will unravel the reasons why the interaction between the audience and virtual tour streaming platforms affects the consumption intention to products at different levels. How do different motivations affect the social capital of the audience? Interestingly, this study utilizes the social capital and social motivation of Sheer and Rice (2017) as the theoretical framework. Based on this premise, this study maintains that the audience can affect the consumption intention by interacting in virtual tour streaming platforms; at the same time, it deems social motivation as an antecedent to social capital. Therefore, the objectives of this study are (1) to investigate how social motivation (vertical motivation and horizontal motivation) in streaming platforms affects social capital (bonding social capital and bridging social capital), and (2) to understand how social capital affects consumption intention of audience.

## LITERATURE REVIEW

### **Consumption Intention of Audience**

This study defines consumption intention as a consumer's purchase and support intention (Chou & Hsu, 2016; Ou *et al.*, 2014). In the traditional model of consumption, the interaction between the buyer and seller takes the form face to face. According to Zhang *et al.* (2011), a dramatic change from the physical mode of transaction to online shopping is associated with numerous challenges such as lack of human interaction, untruthfulness, uncertainty, and the fast spread of reputation. In this age of internet addiction, people are inclined to use virtual tour streaming platforms to find answers to problems, ask questions and share their experiences. It is, therefore, interesting to note that information on products advertised on virtual tour streaming platform affect the consumption intention of the audience (Ou *et al.*, 2014). Studies (e.g., Ou *et al.*, 2014) have revealed that in the past, the consumption intention of the user was dependent on the mode of marketing advertisement in the platform and the resultant effect was an accumulation of capital and knowledge to make decisions. Therefore, in order to trigger the consumption intention of the product, it was a precondition to maintain the interaction between the virtual tour streaming platform and the audience. Extant studies (e.g., Chou & Hsu, 2016; Salehan *et al.*, 2017) have shown that the accumulation of social capital from the quality of the interaction between customer and seller may impact subsequent behavior.

### **Dual Relationship of Social Capital (The Study Concept of Second Year)**

The social capital theory has been employed substantially in different fields (Nahapiet & Ghoshal, 1998) and is analyzed from three main perspectives, which are structural, cognitive, and relational. Essentially, social capital is a relational theory that could be produced by change or communication. Therefore, social capital consists of two main complementary factors, which are consistency and interaction. Significantly, relationship capital arises from interaction culminating in trust, agreement, standard, and reciprocity. This means that the audience of the virtual tour streaming platform shares some level of trust, and this creates sharing of common regulations or values. Interestingly, it also creates grounds to share responsibility leading to long-term tacit understanding, reciprocal behavior, and interpersonal relationship. It is important to underscore that social capital is evident in the physical environment, which includes face-to-face interpersonal interaction. Extant studies (e.g., Sheer & Rice, 2017) have shown that the predominance of virtual tour streaming platforms and the trendy nature of mobile commerce and social media have created a new wave of social capital for the audience. This new order is characterized by a combination of flexibility and dynamics in virtual tour streaming platforms. These have ushered in unparallel built of relationships and have become the nucleus of the concept of social capital (Adler & Kwon, 2002; Boyd & Ellison, 2007; Sheer & Rice, 2017).

### ***Bridging social capital***

Bridging social capital is a situation whereby there is less contact between people, indicating there is a weak relationship among the audience in virtual tour streaming platforms (Sheer & Rice, 2017). Consequently, this weak relationship would create more different opinions and diversified viewpoints as well as messages (Kobayashi, 2010). Bridging social capital is a procedure or mechanism intended to restore the weak relationship evident on the virtual tour streaming platform. (Boyd & Ellison, 2007). Bridging social capital creates enabling environment for people to cooperate and tolerate each other in virtual tour streaming platforms. Interestingly, while social relationship on the virtual tour streaming platform makes it conducive to spreading information and triggering unity, less social interaction generates ill-feeling and conflict on the virtual tour streaming platform. There is a body of literature (e.g., Boyd & Ellison, 2007; Sheer & Rice, 2017) that concludes that bridging social capital is a panacea and creates an enabling environment for virtual tour streaming platforms to thrive.

### **Bonding social capital**

Bonding social capital covers the level of the relationship among individuals and boosts the emotional relationship among the group. The unfamiliarity of virtual tour streaming platforms makes its acceptance lower among other groups comparatively. According to Adler and Kwon (2002), the distinctiveness of a homogenous group is evident, thereby making a heterogenous group apparent. This effect is classified as a negative impact of social capital. Social capital is built on a strong relationship and persistent reciprocity. Bonding social capital can be created and be practiced when there is an emotion or substantial support. The shortcoming is that it will be deemed as isolation and rivalry to other groups (Kobayashi, 2010). For example, a friend who always keeps in touch in a virtual tour streaming platform has a strong relationship characterized by emotional support and obligation. While those who lack these experiences and resources have exclusivity, leading to limit personal choice and the acceptance of information (Adler & Kwon, 2002; Sheer & Rice, 2017).

### **Effects of Audience Social Motivation**

Social interaction motivation is defined as an act of a person that seeks to control and fulfill a requirement (Salehan *et al.*, 2017). The motivation, in this sense, triggers the orientation and strength of the behavior. The actions or behavior of an individual is well calculated and is based on the desires and goals of the person. In other words, one's behavior is triggered by desire before acting. Motivation is therefore based on knowledge, abilities, and skills people acquire and are directed towards a goal. One's motivation determines their participation levels and results, which is tied to subsequent behaviors and resource allocation (Boyd & Ellison, 2007; Salehan *et al.*, 2017; Valenzuela *et al.*, 2009).

#### ***The vertical social motivation of the audience***

Vertical social motivation means a close relationship built on obligation and responsibility with people who share similar ideas (Salehan *et al.*, 2017). Studies have revealed that vertical motivation stems from close relationships built on strong reliance and a sense of trust. In the context of this study, most of the audience maintains this intimate relationship (vertical social motivation) through virtual tour streaming platforms and social media (Valenzuela *et al.*, 2009). Most of the audience share their lives and interact with others in the virtual tour streaming platforms, and this consolidates social activity.

#### ***The horizontal social motivation of the audience***

Horizontal motivation, in contrast to vertical social motivation, is an association with less familiar people and prioritizes establishing new social relationships (Valenzuela *et al.*, 2009). This becomes necessary when there is a sense of trust and unanimity of viewpoints which ultimately triggers conceptual change. Significantly, the generation of horizontal motivation is through the connection established between people with common goals and interests. Consequently, the audience expands their interpersonal relationship and establish their reputation through virtual tour streaming platforms by sharing information and messages with others in a different environment. In other words, if the audience wants to share links through a virtual tour streaming platform, a major precondition is to build a relationship with one another and share common interests. This creates an enabling environment for others to provide related information (Boyd & Ellison, 2007; Salehan *et al.*, 2017).

### **Adjustment Results of Swift Guanxi**

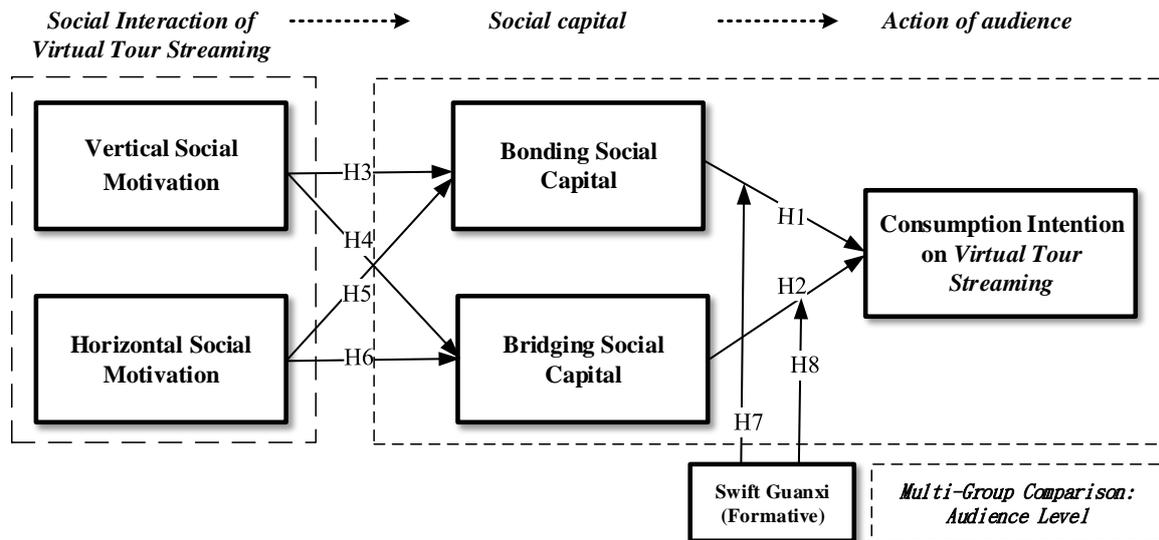
Swift guanxi is an unfamiliar virtual group on social media and has gained popularity in recent times (Ou *et al.*, 2014). However, in traditional settings, establishing a relationship takes time, starting from cultivating feelings and building mutual emotions. This ultimately graduates to mutual understanding and knowing each other better. The establishment of a traditional relationship requires time and cost in this regard. This study employs swift guanxi as a social capital construction in a virtual tour streaming context. Swift guanxi is a revolutionary trend compared to the traditional relationship, which takes time and resources. Swift guanxi thrives on social media, which covers mutual understanding, reciprocal favor, and relationship harmony.

### **Control Variable**

A control variable was included in this study to ensure that the independent variable will not be affected by extraneous factors which have no relation to the study. Therefore, the streaming adoption behavior (audience contribution behavior) in this study may be different when using virtual tour streaming platform; as a result, this study uses participation audience (professional audience and general audience) in virtual tour streaming platform as a control variable (Venkatesh *et al.*, 2003).

### **Research Method and Design**

This study employs the innovative cognitive theory to analyses audience (i.e., professional and general audience) consumption intention in virtual tour streaming platforms. This is done from the lens of benefits, risk, and innovative atmosphere, not excluding social motivation and interaction among the audience. The vertical and horizontal social motivation affect the dual relationship of social capital between the audience in the virtual tour streaming platform. This is actualized and materialized when the content is satisfactory and affects their usage behavior. Thus, the study adopts "social motivation – dual social capital-swift guanxi - consumption intention" to explicate virtual audience tour streaming adoption. The measure of this study is shown in Figure 1. Significantly, the audience consumption behavior of virtual tour streaming platforms is dependent on the dual social capital, which stems from the vertical and horizontal motivations. Consequently, a change in the vertical and horizontal motivations would alter the audience's consumption intention. This is called the 'professional sponsorship audience,' which has a unique class of audience. Therefore, this study uses this conceptual framework based on the literature (see Figure 1).



Source: This study.

Figure 1: Conceptual Framework.

### **Dual social capital relationship and consumption intention**

Bonding capital mainly focuses on the close relationship between individuals and acquaintances. For example, those who are always keeping in touch on virtual tour streaming platforms would have strong emotional support and the relationship of obligation (Sheer & Rice, 2017). In a virtual tour streaming platform, an interaction among acquaintances could develop into long-lasting relationships. Once there is the dissemination of good or bad information, the other party will share and information with each other (Chou & Hsu, 2016; Sheer & Rice, 2017). Therefore, the audience in virtual tour streaming platforms could ascertain the authenticity of the information before consumption.

The rationale for bridging capital on consumption intention is to interact with unfamiliar audiences who have consistent attitudes and opinions through the virtual tour streaming platform to broaden one's horizon and exposure (Adler & Kwon, 2002; Boyd & Ellison, 2007; Sheer & Rice, 2017). Therefore, the reason for bridging capital is to interact with unfamiliar audiences who share common ideas and goals. Consumption intention may change after the interaction with the audience. However, the audience can share the consumption experience by interacting with others in the virtual tour streaming platform. After interacting, bonding capital could be created, which makes the audience gain the target message and have some ideas of the product so as to produce consumption intention. As a result, the opinions of the audience may be an important resource to consumption intention. Research shows that the behavior intention of bridging social capital has a considerable influence on the audience. In other words, bridging social capital is dependent on user behavior and the frequency of audience on the virtual tour streaming platform (Ou *et al.*, 2014; Sheer & Rice, 2017). Therefore, this study proposes the hypothesis below:

*Hypothesis 1: The bonding social capital of the audience in virtual tour streaming platforms has a positive influence on the audience's consumption intention in virtual tour streaming platforms.*

*Hypothesis 2: The bridging social capital of the audience in virtual tour streaming platforms has a positive influence on the audience's consumption intention in virtual tour streaming platforms.*

### **Social motivation and the dual social capital relationship**

Vertical motivation means to have a close relationship with an acquaintance, which thrives on a sense of obligation and trustworthiness (Salehan *et al.*, 2017; Valenzuela *et al.*, 2009). Motivation depends on several factors, as echoed by extant studies. For example, vertical motivation comes from one's acquaintances and depends on the sense of trust and level of familiarity. Many studies point out that participating in virtual tour streaming platforms can bring beneficial social capital to the audience, and the exchange of information is also quite rich (Salehan *et al.*, 2017; Sheer & Rice, 2017). Interestingly, it should be emphasized that vertical motivation and bonding social capital are interdependent (Salehan *et al.*, 2017). Also, it proves that the audience tends to interact with those who they trust to maintain the relationship or acquire new knowledge. As a result, this study proposes the hypothesis below:

*Hypothesis 3: The vertical motivation of the audience in virtual tour streaming platforms has a positive influence on the bonding social capital of the audience.*

*Hypothesis 4: The vertical motivation of the audience in virtual tour streaming platforms has a positive influence on bridging the social capital of the audience.*

Horizontal motivation is deemed as having a connection with those who are less familiar. It may be that they have common and consistent ideas and a sense of trust in each other. In view of professionalism and trust, they may change their ideas. The generation of horizontal motivation is to have contact with those who have common goals and interests within a group. Most audiences expand their interpersonal relationship through virtual tour streaming platforms. They use sharing mechanism to spread information and message to others so as to influence the audience to interact in different environments (Boyd & Ellison, 2007; Salehan *et al.*, 2017). While sharing is not the only way to link with the unfamiliar, there are other ways to ensure interaction among the audience. For example, providing related information comments or sharing daunting tasks or problems could ignite discussions which would ultimately trigger social interaction. Therefore, this study proposes the hypothesis below:

*Hypothesis 5: The horizontal motivation of the audience in virtual tour streaming platforms has a positive influence on the bonding social capital of the audience.*

*Hypothesis 6: The horizontal motivation of the audience in virtual tour streaming platforms has a positive influence on bridging the social capital of the audience.*

#### ***The moderating effect of swift guanxi on the dual relationship between social motivation and social capital***

The predominance and booming of virtual tour streaming platforms are fraught with untrustworthiness, low switching cost, uncertainty, and low reputational issues (Zhang *et al.*, 2011). However, its consumption intention does not necessarily require a thorough understanding of each other as long as they can understand the requirements of the other party. Thus, it can reduce the cost of suspicion. More effectively, the audience consumption intention of virtual tour streaming platforms can be constructed on the reciprocity of the relationship between the parties. Its sustainability is dependent on the benefits accrued by each other. The establishment of the new relationship rapidly in this regard is called “Swift Guanxi” (Ou *et al.*, 2014). While swift guanxi has gradually been valued, the element of “swift” means that when a virtual tour streaming platform is established, the audience may build a sense of trust because of the interaction (Ou *et al.*, 2014; Sheer & Rice, 2017). As a result, this study proposes the hypothesis below:

*Hypothesis 7: Swift guanxi moderates the relationship between the bonding social capital of the audience and the consumption intention of the audience.*

*Hypothesis 8: Swift guanxi moderates the relationship between bridging social capital of audience and consumption intention of audience.*

#### ***The level of differences between consumption intention and audience (professional and general)***

Extant studies (e.g., Karahanna & Preston 2013; Wagner *et al.*, 2014) have shown that audience requirements determine their consumption intentions. Based on this premise, both professional and general audiences have different perspectives on the motivation for dual social capital. Therefore, this study explores the differences in accumulated social capital and motivation between users of different levels (professional audience and general audience) from the perspective of the virtual tour streaming platform when they interact with broadcasters (Salehan *et al.*, 2017; Sheer & Rice, 2017). The consumption intention of the audience may be affected by the different levels of an audience (Ou *et al.*, 2014; Salehan *et al.*, 2017; Sheer & Rice, 2017). Based on this literature, the study proposes the hypothesis below by performing MGA analysis on different audience levels:

*Hypothesis 9: There are different perspectives on the motivation for dual social capital between the professional and general audience.*

## **RESEARCH METHODS, STEPS, AND PROGRESS**

### **Recovery Rate and Object Screening**

In this section, the study designs an interview guide tailored to solicit responses from broadcasters, professional audiences, and general audiences. First, the study targeted catering owners who adopt and use information systems based on big data business analysis systems as the target population for the expert qualitative interview. This was followed by collecting vital data from the big data analysis interface and formed the basis to generate the interview guide. This aided the identification of salient factors which underpinned the development of the questionnaire and its administration. The qualitative approach was followed by quantitative analysis. The themes that were generated from the qualitative approach formed the basis for the items used for the questionnaire development. To ensure the reliability and validity of various aspects of measurement items, the employed scales are based on previous studies in information management. A 7-Point Likert Scale measurement was used to ascertain respondents' actual experiences and feeling. Pretest was done by inviting experts of virtual tour media and related scholars in the field of information management to check the operationalization and validity of the measurement items. The process ensured the content validity and the expert validity of the questionnaire. Finally, the pretest was followed by piloting the questionnaire with thirty audiences who are conversant with virtual tour streaming platform environments to clarify whether there are hidden ambiguities in the questionnaire items and then revise the questionnaire accordingly. The study purposely targeted accurate streaming industry audiences to fill in the questionnaires. As suggested by extant studies (e.g., Bhattacharjee, 2001; Hair *et al.*, 2018), the study purposely targeted respondents who are the audience of the virtual tour streaming platforms via online questionnaire administration as well as self-selecting by posting it on social media platforms. Therefore, this research adopts online

questionnaires to solicit data. To enhance the quality and accuracy of the data collection, an explanatory video was embedded in the online questionnaire to explain key concepts before commencing the answering of the questionnaire.

In the first step, the qualitative procedure of this study employed the snowball sampling technique to select participants (professional and general audience of virtual tour streaming platforms) for the interview session, which generated the key factors for the study. In the second year, which employed the quantitative approach, the research questionnaire was divided into two parts. These include the first section, which covered 'Basic Information' and 'The Difference in Audience Level.' The research variables in the second section include 'Consumption Intention in Virtual tour streaming Platform,' 'Bonding Social Capital,' 'Bridging Social Capital,' 'Vertical Social Motivation,' 'Horizontal Social Motivation,' and 'Swift Guanxi.' The 7-point Likert scale was employed in the second section to solicit responses ranging from "strongly disagree" to "strongly agree." While the first part of the questionnaire, i.e., "Basic Information" and "The Difference in Audience Level," are both nominal scales.

### **Formative indicator analysis**

PLS (Partial Least Squares) can deal with both reflective and formative indicators at the same time. To perform measurement model analysis for formative items scale, weights of the items are analyzed while the factor loadings and average variance explained is ascertained in the case of reflective indicators. In terms of formative indicator, the concept is based on the integration basis of the measurement indicator. The formative measurement indicators jointly determine the meaning of the construct. Thus, if a certain indicator is missing from the measurement, the concept of the construct is incomplete. When a potential variable is constituted by a formative indicator, the indicator will affect the potential variable, and it will not have an influence on individual indicator (Hair *et al.*, 2012; Ringle, Wende, & Becker, 2015). This study adopts a two-stage approach to analyze reflective - formative indicators. In the first stage, it uses the repeated index method to obtain the potential variable score of the first-order reflective variable, which can be used as the observation variable of the second-order formative indicator. It then performs subsequent analysis and conducts the second-order formative analysis of swift guanxi variable, including first-order dimensions such as "Mutual Understanding" and "Reciprocal Favor" and "Relationship Harmony." However, the treatment of the first-order variable of this study adopts reflective indicators for analysis (Hair *et al.*, 2018; Ou *et al.*, 2014).

### **Data analysis and hypothesis verification**

The study adopts Smart PLS 3.0 (Partial Least Squares), which has been used widely in information system and related studies for measurement and structural model assessments (Hair *et al.*, 2018; Jöreskog & Wold, 1982). PLS is a component-based Structural Equation Modeling and is designed to investigate path coefficient of the research model, and the structural relationship of a potential variable based on nonparametric approach (Ahuja & Thatcher, 2005; Chin *et al.*, 2003; Hair *et al.*, 2013). It can perform a robust test on statistical data with small samples and abnormal characteristics (Ahuja & Thatcher, 2005; Wynne W Chin, 1998; Hair *et al.*, 2018). PLS adopts the bootstrap method to avoid the prediction risk that the estimated coefficients will be affected by the traditional multiple regression method due to the small number of samples. In this research, the value is proportionally increased according to the actual number of samples, which can be used to set up the sample value for a repetitive sampling of bootstrap and adopts the setting method for the following repetitive sampling recommended by Lohmöller (1982) and Hair *et al.* (2013): (1) more than an original number of samples (2) the maximum number of samples for repetitive sampling is 5000.

## **RESULTS**

### **Expected Contribution in this Research**

Social capital discusses the degree of relationship with people in real life and could equally be used in the context of a virtual tour streaming platform and its audience. Applying virtual tour streaming in this regard, the study shows that whether the familiarity or otherwise of the audience, there is the interaction among actors in the virtual tour streaming audience. It was found that people are inclined to conform to things that are introduced by their friends and relatives, and this ultimately affects their consumption intention. This echoes the concept of social capital and discusses the impact of different levels of capital on subsequent contribution behavior. Thus, it is vital to interact with the audience in a virtual tour streaming platform to ascertain the differences in the audience level (i.e., professional and general audience) as well as the degree (stronger or weak) of the relationship to mitigate uncertainty and enhance consumption intention.

The resources provided in the virtual tour streaming platform would affect the adoption behavior of the audience. Social capital is dependent on mutual benefit and understanding and promotes contribution intention. The aim of this study was underpinned by the contribution intention of the audience because virtual tour streaming platform has become a vital way for people. The need for the audience to gain resources informs their behavior to interact with others. Thus, the study has shown that different motivations of the audience explain their accumulation of social capital and affect their subsequent contribution behavior. The audience should have access to a vast array of information, and an enabling environment should be created for the interpersonal relationship to thrive. This way could help the audience to have a solution to problems they confront via a virtual tour streaming platform. By influencing the in-depth interaction and the influence of swift guanxi, the impact of the subsequent adoption behavior between the audience and the virtual tour streaming platform is strengthened. This expected contribution is consistent with the social capital theory of the bonding/bridging framework of the consumption intention, and different level audiences evaluate the vertical and horizontal social motivation with swift guanxi's interaction effect on virtual tour streaming. Therefore, the results of this study are consistent with our proposed research model.

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# Automatic Recognition of Knowledge Characteristics of Scientific and Technological Literature from the Perspective of Text Structure

(Work in Progress)

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## ABSTRACT

This paper independently explores the chapter structure of scientific and technological literature in the field of shipbuilding in the natural sciences and the field of library and information in the social sciences. The chapter structure model of previous studies, namely 'background, purpose, method, result, conclusion, demonstration,' is quoted as the verification object of the document chapter structure in the field of exploration. In order to verify the rationality of the structure, this paper uses the deep learning models TextCNN, DPCNN, TextRCNN, and BiLSTM-Attention as experimental tools, and designs 5-fold cross-validation experiment and normal experiment, and finally verifies the rationality of the model structure, and It is concluded that the BiLSTM-Attention model can better identify the chapter structure in this field.

*Keywords:* Shipbuilding, library and information, chapter structure, deep learning; cross-validation.

## INTRODUCTION

With the development of network information technology, scientific and technological resources are accelerating the pace of increase in quantity, variety, and distribution. As a result, during this period of time, a large amount of literature resources was not utilized in a timely and effective manner, which means that the value of literature has been weakened. Therefore, it is necessary to propose and improve the method of extracting the knowledge features of scientific and technological literature and automatically identifying the structure-function. Because it can help readers quickly understand the chapter structure and knowledge features of related documents in the field and improve the efficiency of the use of literature resources.

In this paper, the excavation of the text structure is actually based on the characteristics of the literature resources. The current feature recognition research of literature resources mainly uses methods and technologies such as natural language processing based on text classification and machine learning to automatically recognize the structure of the literature content.

Some scholars have the following opinions on what method is used to identify the text structure. First, Zhang *et al.* used characters as the data input unit and used deep learning of convolutional neural network to extract abstract semantics of character-level data. And achieved the purpose of the deep learning model for text understanding (Zhang & LeCun, 2015). Dasigi *et al.* used deep learning models such as RNN and LSTM to identify the structure of scientific and technological literature. Jung proposed to apply supervised learning technology (a technology of machine learning) to the semantic features of the main content of scientific and technological literature to identify. The first two researchers used deep learning methods, and the latter one chose one of the machine learning methods. Which of the two methods is better? Li Nan, Fang Li, etc., compared the performance of SVM, CRF, and NBC classification models in the field of machine learning and models represented by CNN and RNN structures in the field of deep learning. The results show that CNN, LSTM, LSTM+CRF, LSTM+SVM, CNN+CRF, CNN+SVM based on deep learning have better performance. In addition, Qin Chenglei *et al.* (2020) compared the three models of Bi-LSTM+CNN, Bi-LSTM+Attention, and Bi-LSTM+CNN+Attention, and proposed the performance of the deep learning model after adding hierarchical attention (Attention) better.

Then, this paper adopts the method of deep learning field as the experimental tool and adopts the TextCNN, DPCNN, TextRCNN, BiLSTM-Attention model, which contains CNN and RNN structure in this field as the experimental tool (Fesseha *et al.*, 2021; Wang *et al.*, 2019);

Many scholars conduct research on text structure from different angles. For example, Lu Wei, Huang Yong, etc., studied the structural function recognition of academic texts from three different perspectives: chapter title, chapter content, and paragraph. However, Dasigi *et al.* only studied the composition structure of scientific and technological literature content from the sentence level. Then, Qin Chenglei and others carried out word-level, sentence-level, and paragraph-level structure recognition on scientific papers and concluded that the sentence-level level is more appropriate. Finally, this paper decides to explore the

characteristics of the chapter structure of the literature in the shipbuilding field and the library and information field from the sentence level.

In summary, the general work of this article is as follows:

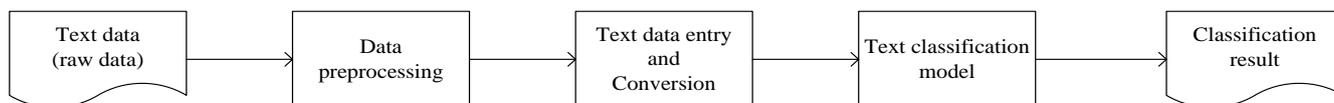
1. Construct a dataset in the field of shipbuilding and library and information.
2. Self-optimization of four models (parameter adjustment).
3. Comparison and analysis of experimental results of four optimized models.

### RELATED THEORIES AND TOOLS

In this paper, the recognition of the chapter structure of scientific and technological literature in the field of shipbuilding and library information is based on the method of text classification. Wang Dongbo *et al.* proposed that the problem of sequence labeling of sentence units and the problem of academic text structure-function recognition can be converted to each other, and the realization of the two can achieve the same purpose. This means that the structure of the entire document can be identified by identifying the sequence to which the sentence unit belongs. As a result, the paper uses sentence-level sequence annotation to achieve the recognition of the document text structure, that is, the text classification method.

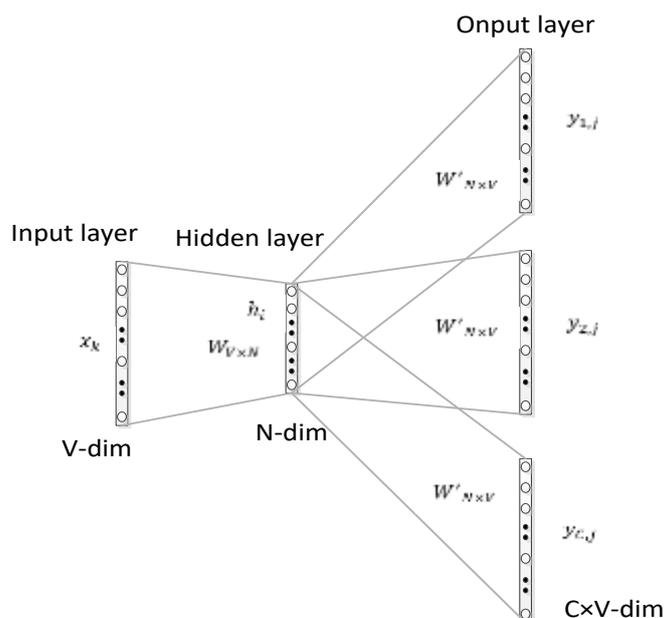
For text classification, first, the original data needs to be preprocessed so that the data obtained is sentence-level data with sequence tags. In the process of data preprocessing, it is necessary to remove the noise data and standardize the length of the text to ensure the quality of the data. Since the computer cannot directly recognize the text data automatically, and in order to reduce the burden of the computer, the text features of a whole sentence cannot be used as input. All, it is necessary to segment the sentence-type data so that important text features in a piece of data can be extracted. Then the divided words are converted into word vectors as the input of the computer.

For the word segmentation tool, this article uses Jieba word segmentation. The word vector conversion of the data afterword segmentation adopts the skip-gram model in the word2vec tool. Using word2vec is to express each word obtained by dividing text data into a unique word vector with a unified meaning and dimension. The essence of word2vec is a method of word clustering, which is suitable for sequence data and is also a simple (input layer-hidden layer-output layer) neural Network model. The skip-gram model takes the word vector of a word as input and predicts the context of the word. Figure 1 describes the general process of text classification, and Figure 2 shows the Skip-gram model.



Source: This study.

Figure 1: The general process of text classification



Source: <https://blog.csdn.net/u010665216/article/details/78721354>.

Figure 2: Skip-gram.

## CONSTRUCTION OF SCIENTIFIC AND TECHNOLOGICAL LITERATURE DATASET

### Data sources

As this article studies two scientific and technological literature fields, it is necessary to construct two datasets, namely the shipbuilding field dataset and the library and information field dataset. The scientific and technological literature in the field of ship construction comes from CNKI's literature resources in the past five years. Because the length of the dissertation is too long, academic papers are selected—a total of 173 scientific and technological literature resources in the field of shipbuilding selected by CNKI. The scientific and technological literature in the field of library and information comes from the literature resources of the library and information papers network in the past five years. In the field of library and information, 198 literature resources on library construction are selected.

### Data preprocessing

Two datasets are obtained by removing non-critical information, sentence division, noise data removal, and short texting of long text data from the text data in the two fields. And the shipbuilding field dataset has a total of 10,680 records, the library, and the information field. The dataset has a total of 13,083 records.

### Annotation result statistics

Manually label the processed data, and the computer learning rules can learn the rules only on the premise of the existing rules, so the process of data labeling is indispensable. The principle of data labeling is the chapter structure model adopted in this article. Table 1 is the definition of each part of the text structure model, and Table 2 is the statistics of the annotation results of the two datasets.

Table 1: The text structure.

Structure category	Definition
Background	Time background, theoretical background, including descriptions of past, present, and future situations.
Purpose	Put forward a clear goal that needs to be reached, including the improvement of technical level and feeling level, etc.
Method	All technologies, suggestions, etc., are adopted to achieve a certain purpose.
Result	The result is caused by the realization of the method or the unrealized phenomenon, which exists in itself
Conclusion	The author's summary of the above four parts
Demonstration	A method that can be used to prove an argument. The deduction from the argument to the topic in the proof is carried out in the form of reasoning, sometimes a series of reasoning methods

Source: This study.

Table 2: Annotation result statistics.

Category	Amount	
	Shipbuilding dataset	Library and information dataset
Background	1981	1821
Purpose	1289	1049
Method	865	1280
Result	2064	3348
Conclusion	2030	3262
Demonstration	2451	2323
Total	10680	13083

Source: This study.

## EXPERIMENTAL DESIGN AND IMPLEMENTATION

### Experimental standard

The experimental standards used in this article are accuracy rate Acc, recall rate R, and F1 value. In the following formula, TP represents the amount of text data whose actual and predicted categories are both positive. FP represents the amount of text data whose actual category is negative, but the predicted category is positive. FN is the amount of text data whose actual category is positive, but the predicted category is negative. TN is the amount of text data whose actual and predicted categories are both negative.

$$Acc = \frac{TP + TN}{TP + FP + FN + TN} \quad (1)$$

$$P = \frac{TP}{TP + FP} \quad (2)$$

$$R = \frac{TP}{TP + FN} \quad (3)$$

$$F1 = \frac{2 * P * R}{P + R} \quad (4)$$

### Experimental model parameter adjustment

Before the TextCNN, DPCNN, TextRCNN, and BiLSTM-Attention models are used for text classification of experimental data, and each model needs to undergo a self-optimization process to ensure that the experimental results of each model are compared under the optimal conditions of the self-model. The self-optimization process of the model is actually the process of adjusting many parameters of the model. The specific process of parameter adjustment is displayed through four parameters. Table 3 below shows the final setting details of various parameters of each model.

Table 3: Experimental model parameter setting.

Model Parameter	TextCNN	DPCNN	TextRCNN	BiLSTM-Attention
sequence length	300	200	200	200
vocab size	5000	5000	5000	5000
hidden size	-	-	224	128
hidden size2	-	-	-	64
embedding dim	300	300	300	300
num filters	288	180	-	-
num layers	-	2	1	2
filter size	[2,3,4,5]	-	-	-
num classes	6	6	6	6
learning rate	1e-3	1e-3	1e-3	1e-3
batch size	64	32	32	32
num epochs	13	17	12	13
activation_func	relu	leakyrelu	leakyrelu	leakyrelu
require_improvement	1000	1000	1000	1000

Source: This study.

## EXPERIMENTAL RESULTS

### Normal result

First, the experimental model is set according to the parameter values in the above table. The datasets of the shipbuilding field and library information field are respectively divided into a training set, val set, and test set according to 6:2:2. Among them, the data of the training set is used to train the model so that the model continuously extracts the corresponding rules from the data of the training set. The data in the validation set is used to test the quality of the model training with accuracy, recall, F1—the value as the standards. The test set is used to test the actual performance of the model. The specific results of the experiment are divided into two parts: the recognition result of the ship construction dataset and the recognition result of the library and information dataset. Not only need to obtain the specific results of text data recognition but also to obtain the model—the recognition result. The results are shown in Table 4.

Table 4: Normal experiment result.

Shipbuilding dataset				Library and information dataset			
Model	Acc	R	F1	Model	Acc	R	F1
TextCNN	0.9433	0.9447	0.9440	TextCNN	0.9746	0.9618	0.9682
DPCNN	0.8673	0.8297	0.8481	DPCNN	0.9109	0.9218	0.9163
TextRCNN	0.9562	0.9488	0.9525	TextRCNN	0.9831	0.9788	0.9810
BiLSTM-Attention	0.9641	0.9660	0.9651	BiLSTM-Attention	0.9863	0.9789	0.9826

Source: This study.

### 5-fold cross-validation experiment result

Using the 5-fold cross-validation method to evaluate the performance of the model can prevent over-fitting to a certain extent, and the cross-validation method can obtain as much information in the data as possible. The basic idea of the 5-fold cross-validation method is: First, divide the data into five equal parts that basically meet the average requirements, and each piece of data is mutually exclusive. Then, turn each piece of data as the test set in turn, and the remaining four. The dataset is merged into

the training set. In the second experiment, there is no division of the validation set, only the training set, and the test set. Unlike Experiment 1, this experiment allows each piece of data to be used as a validation set, increasing the number of model training and taking the average of the model performance. The value evaluates the performance of the model and has certain feasibility. Since the application of the 5-fold cross-validation method is not the purpose of the experiment in this article, the second experiment is only a verification or supplementary explanation of the results of the first experiment. Therefore, take the training set in the first experiment as all the data in this experiment. The experimental results are shown in Table 5.

Table 5: 5-fold cross-validation experiment result.

Shipbuilding dataset				Library and information dataset			
Model	Acc	R	F1	Model	Acc	R	F1
TextCNN	0.9001	0.883	0.8914	TextCNN	0.8549	0.8876	0.8709
DPCNN	0.8045	0.7851	0.7947	DPCNN	0.795	0.8207	0.8076
TextRCNN	0.9000	0.8839	0.8919	TextRCNN	0.8577	0.8904	0.8737
BiLSTM-Attention	0.9021	0.8849	0.8934	BiLSTM-Attention	0.8584	0.8934	0.8756

Source: This study.

### CONCLUSION AND FUTURE RESEARCH

Through the analysis of the two experimental results, the following conclusions are drawn.

- 1) Judging from the recognition accuracy rate of various models, the accuracy rate is about 90%, indicating that the six-term structure adopted is in line with the chapter structure of the literature in the research field.
- 2) The model based on the RNN structure is more suitable for the identification of the text structure of the documents in these two fields than the model based on the CNN structure.
- 3) A comparison between the TextRCNN and BiLSTM-Attention models based on the RNN structure shows that the BiLSTM-Attention model that introduces the attention mechanism has a better recognition effect.
- 4) The reference of the attention mechanism helps to improve the accuracy of classification and recognition under certain conditions.
- 5) In the process of text classification and recognition, the deep learning model can also improve the accuracy of classification and recognition by enhancing the long-distance capture of text information. That is, the bidirectional RNN or LSTM model can capture text information for a long time and long-distance.

In the end, this paper draws a text structure model for the scientific and technological literature in the field of shipbuilding and library information to be explored. The experimental results are reasonable and feasible, and the BiLSTN-Attention model based on two-way long-term and short-term memory and introducing the attention mechanism is more suitable. The recognition of text structure based on knowledge feature vector in these two fields.

This article only uses four models as experimental tools, the number is limited, and the experimental data may have human errors, so the experimental process needs to be further improved, here is mainly to provide a case for follow-up research, hope that follow-up researchers can check the omissions. Further, supplement it.

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## **Data Governance in Data Mesh Infrastructures: The Saxo Bank Case Study**

*(Work in Progress)*

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### **ABSTRACT**

Data governance (DG) is the management of data in a manner that the value of data is maximised and data related risks are minimised. Three aspects of DG are data catalogue, data quality, and data ownership and these aim to provide transparency, foster trust, and manage access and control the data. DG solution involves change management and alignment of incentives and mere technology is not enough to address this. In this paper we aim to provide a holistic view of data governance that is a synthesis of academic and practitioner viewpoints, and conclude by giving an example of a pilot case study (Saxo Bank) where authors worked on tech and cultural interventions to address the data governance challenges.

*Keywords:* Data related risks, trust in data, change management and alignment of incentives, governance

### **INTRODUCTION**

The modern organisations have evolved and are marked by some salient characteristics such as partner ecosystem, advent of platforms that require seamless exchange of data with other organisations, and desire to innovate. This requires flexibility and easier access to data. Moreover, the regulatory requirements are complex and tightening giving rise to closer control of data, and obligation to protect the security and privacy of the data subjects. Besides, data is growing humongously and may be lodged in disparate systems in the organisations. This can lead to silos resulting in obstacles to compliance and poor decision making. If the data governance is lax, there are risks of data breach and regulatory violation that can result in financial implications via lawsuits and regulatory fines. IBM estimates the global average cost of a data breach as \$4.24M and the average cost per lost or stolen record in a data breach as \$148 M (Ponemon, 2018). As per Dharni (2018) Google ended up paying a fine of £50 million to the EU, Uber \$148 M, and Marriott International £110 to regulators for non-compliance.

Bischoff (2019) states that organisations not only pay financially for data breach- it's a huge brand hit and loss of reputation. A study of companies trading on the NASDAQ found that the share price of the companies with a data breach was an average of 13% lower than the Index three years after the incident. On the other hand, too tight data governance stifles productivity and innovation. Hence Data governance is extremely important in the right flavor- not too lax and not too tight.

Furthermore, the data landscape is changing- data is moving to the cloud and older relational structures are not able to keep up. Organisational structures are evolving- more and more business teams have analysts, and the core data team is confined to data infra. Then, different functions in the organisation are using data to different means and the core data team is not able to satisfy the demand of switching business contexts for which they have no expertise. This leads to data latency and business is looking to lower tech barriers so that they have quicker access to data for decision making.

That is where the concept of Data Mesh comes in. Dehghani (2020) defines that Data mesh is a decentralized socio-technical approach to manage analytical data at scale. However, this demand for data democratisation puts pressure on centralised governance. If data were to be democratised, governance has to be federated.

### **PROPOSAL**

#### **How do we intend to approach the problem**

For a long time, governance has been a centralised and a tightly controlled function. If this were to be federated, there needs to be a specific plan rooted in the principles of DATSIS: discoverable, addressable, trustworthy, self-describing, inter-operable & secure data, as described by Balnojan (2019). Data governance has to keep a delicate balance with just enough governance to avoid the loopholes but encourage productivity and address demands of decentralisation. Good federated data governance can answer security and governance vows by providing efficient and transparent controls over data that the regulatory environment obligates and also support federated delivery by making data visible and trustworthy. This can facilitate decentralised data ownership.

### **Federated Data Governance in data mesh infrastructure**

To inspire trust in data, the data governance strategy should address three key aspects: discoverability, security, and accountability. This can be done by putting in place federated data governance based on data catalog and data quality framework. The idea is that the organisations should understand the data they hold.

Data ownership is another key part of this equation. This reduces silos and need for human touch points. We envisage that federated data governance should consist of below elements.

#### ***Data Catalogue (DC)***

Data catalogs are descriptions of data and serve as an inventory of metadata giving users the information necessary to evaluate data accessibility, health, and location. With self-service business intelligence, data catalog is a powerful tool for data management and data governance. Catalogues assist in locating relevant data and charting clear data representation hence help a user decide how she can use data. The constituents of DC are technical metadata, ownership information, data lineage, and Business Glossary. Technical metadata describes how the data is organized and the structure of the data objects such as tables, events, objects, attributes with their types and lengths, indexes, and connections. Ownership Information captures the relationship and origin of data. Data lineage (DL) facilitates distributed discovery- one can get the right information at the right time and draw connections between data assets with lineage. Business Glossary (BG) establishes common understanding of business terms in the organization hence prevents misunderstanding by misinterpretation.

#### ***Data Quality (DQ)***

While there are divergent views, we think DQ is a subset of Data governance. Self service DQ includes ability to define and implement quality rules. A gap in DQ leads to lack of credibility of data and loss of business opportunities owing to Dark data assets. In this model, end users are empowered to export, report, and edit the quality rules. Net-net, people who manage data actually understand the data they manage hence breaking the silos.

#### ***Data Ownership (DO)***

The federated data governance requires change management and alignment of incentives and mere technology is not enough to address this. Hence data ownership is a necessary requirement. This facilitates systemic change and helps create data culture, enabled by personas such as Data Steward, Data Product Manager, and Data Domain Owner.

Although Data Mesh has become a popular concept in the industry, there is only one scientific paper “Data-Driven Information Systems: The Data Mesh Paradigm Shift” (Machado et al, 2021), and no contributions in the scientific community on Data Governance in Data Mesh Infrastructure. This contribution is important to build a framework for this emerging concept and this will allow organizations and practitioners to design and implement federated data governance within the Data Mesh paradigm.

### **POTENTIAL IMPACT AND CHALLENGES: FEDERATED DATA GOVERNANCE**

#### **Maximizing the Impact: What are the business cases?**

Some very clear business cases that emerge for federated data governance: expansion of partner ecosystem (such as open banking, marketplaces, and many more), regulatory requirements and compliance, innovation (ability to experiment by reducing time to market, monetization of data assets), improving user experience, reducing the dependence on core data team hence lowering the tech barriers in the organisation.

#### **Challenges: Why is this so Hard?**

For attaining intelligent federated data governance, an organisation has to solve some crucial challenges that are a mix of technical and social, making it so hard. Firstly agreement and compliance to the governance in a dynamic policy environment is a moving target. Then, getting business and technology on the same page is very important because the need for self-serve tools and reorganisation is best driven by business, not tech. Furthermore, seamless integration of tooling with the existing data ecosystem is tough. In our experience, available tools may not map exactly to the organisational needs. Selecting the right tool befitting the unique needs and the seamless integration become extremely important. Then creating data culture and change management is a humongous task. Culture and change management is usually the hardest part in any equation. It requires partnership at multiple levels and buy in from the top management. A mesh of structural, procedural, and relational interventions can be a potent remedy.

### **IMPLEMENTATION OF DATA GOVERNANCE: A CASE OF SAXO BANK DATA WORKBENCH PLATFORM**

#### **Problem Statement/ Business problem**

At Saxo Bank, the focus is to democratize trading and empower clients with information and agility to act. Thus good quality and real-time data is imperative to facilitate clients, while managing risk and compliance. Whilst enterprise-wide adoption of Kafka helped this, the need to govern, catalog, improve, and publish the data quality transparently became more acute. This made Saxo an ideal case study. The hypothesis was that the sound data governance will:

First, enhance data quality by providing data governance, data cataloging, & data quality management in the platform as-a-service. This should be measurable via improvement in data quality measure for data assets under governance.

Second, reduce time to market by ensuring that data assets are discoverable and searchable, cataloguing data assets, enabling transparency, and providing easy to use self service tools to domain teams.

Third, facilitate integrations by following internationally agreed standards for data assets. So that it is possible to avoid integration issues by expanding schema to associate the data products and data elements with industry standard business ontologies. Fourth, ensure ‘Saxo as first WLC (White Label Customer) principles’ in all operations.

**As is state analysis and Stakeholder Engagement**

The journey started with understanding the vision and the key drivers that led to data governance implementation in the organization. Next step was to assess the current state before diving into any solutioning. Saxo had Kafka as the authoritative data source platform. The solution needed to enable governance for the data products published on Kafka. Conceptual diagram of ‘As is state’ is as following:

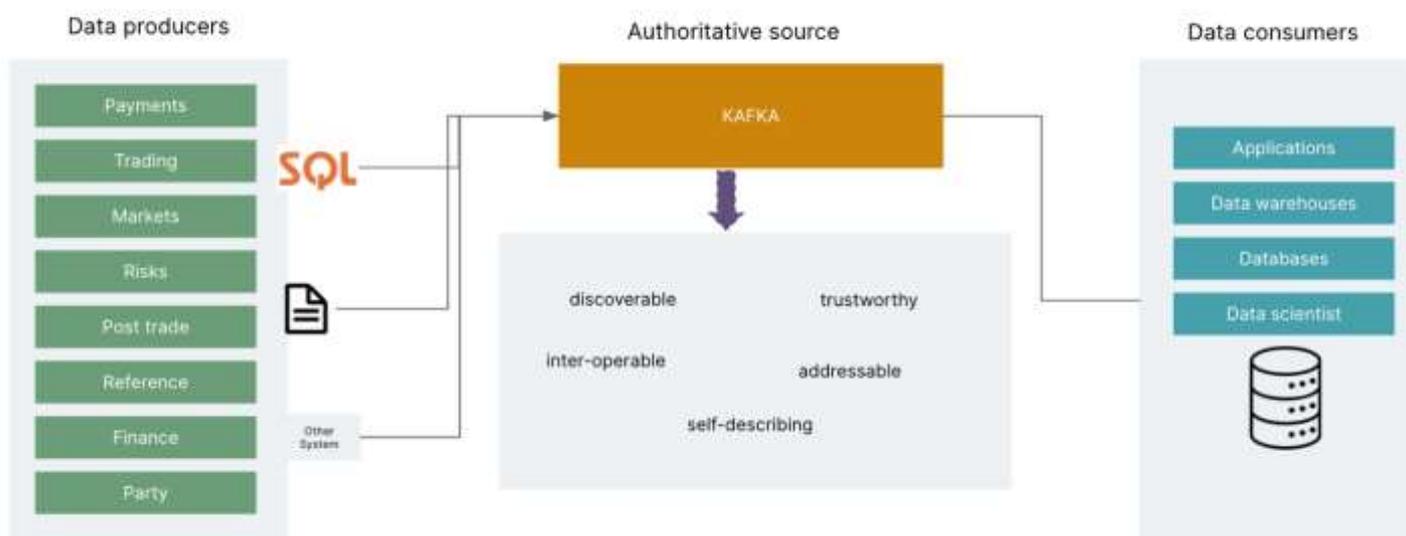


Figure 1: Conceptual Diagram of As is state

This understanding helped create the functional features roadmap. This was supplemented by workshops with key stakeholders and persona Interviews with different data stakeholders to document the pain points and goals. The resulting feature matrix contained expectations from the data governance solution with priority and criticality of the features.

**Priorities for Solutioning Principles**

Business, process, technical, and financial priorities were taken into account. Business priorities included world class Saxo experience, packaging and selling asset management products, introducing money making logic and subscription models to the clients, Industrializing the Saxo solutions wholesale offering. Process wise, federated governance and self-serve platform were the priority. Technical priorities were alignment with Data Mesh and current kafka implementation. Financial priorities were assessing total cost of ownership and reducing operation cost.

**Solution Recommendation**

Based on the above factors, open source LinkedIn Data hub for metadata and GreatExpectation for Data Quality were shortlisted. The conceptual framework looked

**Tool Selection Approach**

The selection needed to be contextual to the organization, data mesh, domain ownership, and light touch governance framework. Below are the details of the steps of the process, Hence a feature matrix reflecting the gap analysis in the existing data ecosystem, stakeholders priorities, and feature expectations from the tool was created. Then, an analysis of in-house vs COTS vs open source was done. For commercial tools, evaluation of organizational maturity is important to get a clarity on what out of a long list of COTS features will be used. Other important parameters were flexibility in customization, cost of supporting the tool, and

deployment options. In the case of open-source tools, first consideration was the current features supported, then the community behind the tool, roadmap visibility, architecture, and extensibility of the tools were evaluated.

An extended analysis on the shortlisted tools was done by performing the spikes (for open source tools). Below were the tools shortlisted and analysed:

Data Catalog: Collibra, Alation, Data.world, Zeenea, Marquez, Amundsen, and Great Expectations

Data Quality Informatica IDQ, Trillium DQ, AWS Deequ, Apache Griffin, LinedIn Data Hub

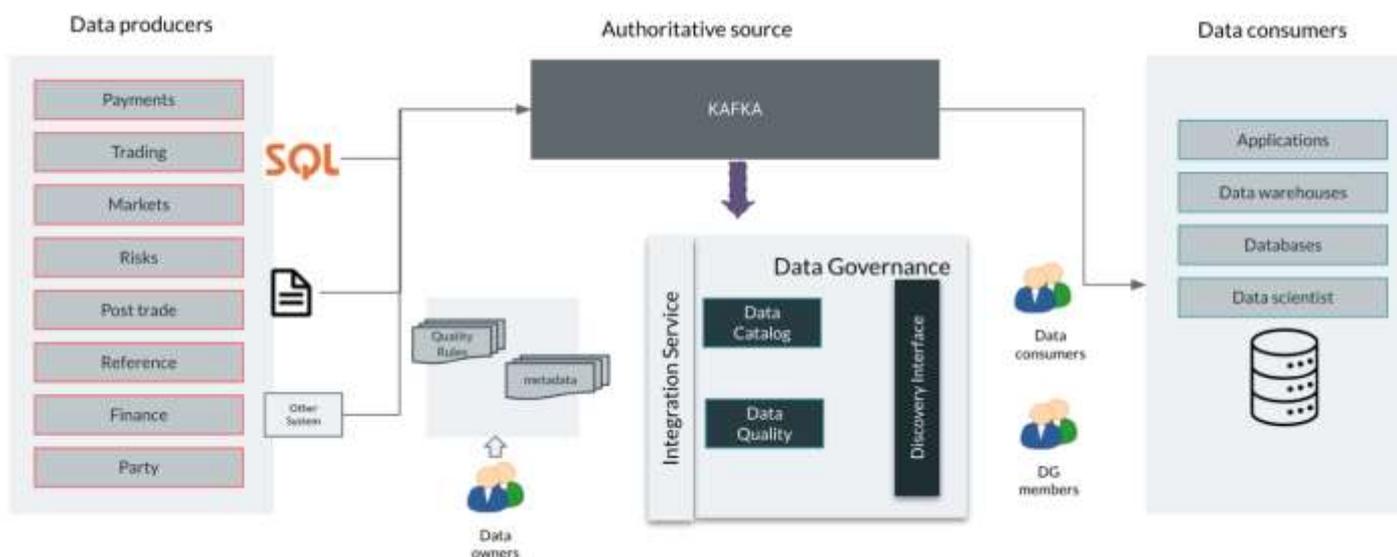


Figure 2: Conceptual Diagram of the Proposed Solution

### Implementation Approach

A two parts approach was taken: Installation & configuration of the tools in the existing ecosystem and implementation of the Data Catalog and Data Quality Solution.

For integration of the tool, one important consideration was that Saxo was the first organisation to implement LinkedIn DataHub in the Kubernetes environment thus the open source libraries were extended to deploy in the Kubernetes cluster.

Furthermore, the DevOps pipelines for deployment of the tool were created with automation- for a self-serve capability. This was a step to leverage the product upgrades with minimal effort. Then, a forking/synching strategy was created to keep up to date with new features. Finally, the observability was implemented by exposing the logs and metrics from all the services to ELK platform and the alerts for failures/errors/warnings were configured.

For implementation of Data Catalog and Data Quality solution the key principle of push based metadata acquisition was followed, in-line with the datamesh principles. i.e. The domain teams are responsible for publishing the metadata (armed with necessary self-serve capabilities) and they know their data better. The open source tools were extended for containerization and the same was installed & configured in the Azure AKS environment. Metadata onboarding efforts were minimized because, otherwise, bringing the datasets into the Kafka platform requires an on-boarding process. The solution extended the onboarding process to collect additional information (such as dataset ownership etc), reducing the efforts to onboard metadata to minimum. The integration layer was created to extract the metadata from the onboarding templates/forms, the schema/structure was extracted from the Avro/Proto schema definitions and transformed the same into the expected format/structure of the product to fill the data catalog.

### Data Catalog

Implementation of the data catalog included bringing the technical metadata, ownership, lineage and business glossary, pushing the metadata repository through defined API/interfaces, and making the same available through discovery interface.

For Technical Metadata, the dataset information was extracted from the dataset (topic) definition files and the structure/definition of the data elements from the associated schemas and pushed to the metadata repository via product API/interface. Then the templates were enriched with ownership information and the same were extracted and associated with the dataset in the metadata model.

LDH provided the support for data lineage. Dataset level lineage was implemented to help visualize/navigate the lineage of a dataset with the parent and with the derived datasets. The lineage was re-worked to foster better representation by a combination of extending the onboarding templates and discovering the Kafka DataHub connector configuration, and a mix of user provided and discovered information was used for building the upstream relationships and the same was pushed to the metadata repository.

### ***Business Glossary***

Implementation of the Business Glossary presented unique issues: LinkedIn DataHub didn't support the business glossary. Saxo team was keen on getting business terms as the first class citizen to enhance the metadata and to resolve data quality issues that arise due to inconsistent nomenclature. The kafka onboarding already had FIBO definitions for the data elements while onboarding the schema. Building on the existing Kafka schema onboarding process, design of the business glossary was proposed. Next step was to Introduce and onboard the new entity into the LinkedInDataHub entities for business glossary).

First, new entities were designed and implemented to model business glossary (glossary nodes, terms and relationships) in the open source product. Saxo uses the proto format to define the schema and it is a rich source of business concepts/definitions. Solution enhanced the proto options to capture additional metadata in the schema (proto definition files) that in turn helped enrich the glossary. This enabled users to discover the datasets through business terms/concepts and also discover the relationship b/n terms.

### ***Data Quality***

For Data Quality implementation, the DSL was defined to facilitate the data producers to create the quality rules and pushed these to the respective domain repository. Pipelines were built to provision the automated jobs based on the onboarded rule definitions to perform the data quality checks and emit the quality results to designated Kafka Topic. Quality results/metrics are collected from Kafka topics and then pushed to metrics stores (elasticsearch) and the same metrics are made available to producers/consumers through Kibana dashboard. This allowed domain/product teams to focus on documenting the quality rules and not worry about the building of the data quality jobs. Dashboards/metrics were provided to empower users.

### ***Data Domain Ownership***

Saxo Bank is committed to assimilating data governance across the organization. Milestones in this journey included formulation of DG committee, defining roles and responsibilities, and creation of domain ownership model (domain teams are responsible for owning and managing the data). The responsibility started from documenting the data products, classifying the data appropriately, and enabling publishing the data products via kafka to the consumers. Domain teams now own their respective repositories that manage the life-cycle of the data. Each data product contains the ownership definitions (both business and technical). While onboarding the data products, teams define the schemas, relate it with the business terms, and classify the dataset attributes.

### ***Solution Outcomes***

As Consumer, user is able to discover the data products, view the metadata, view data lineage to understand the data flow better, view quality snapshot along with metadata and able to access to quality notifications/alerts for the datasets of interest

As a data product owner, a user is able to link data products/elements to the business terms, that encourages the consumption and avoids data inconsistencies, define information classification at data element level, and profile the data before onboarding to Kafka.

Net-net, Data Workbench platform of Saxo enables the domain teams to publish transparent and trustworthy data for the consumers and will pave the way to onboarding of new partners with increased confidence. This is a big milestone in the journey of open banking.

## **CONCLUSION**

In our view good federated data governance is critical because poor practices in controls have significant negative impacts on stakeholders and wider society and on the other hand, excessive controls stifle productivity. Federated data governance inspired by data mesh principles is scalable, self served, and self owned. Clear ownership gives better control on quality.

We think the issue merits a broader view than just technology and is cross-cutting, involving organisational incentives. This presents a unique opportunity to use technology and ways of working to quantify and drive out risks and bias in data driven solutions. Data mesh is an answer to these. Overall, good solutions require diverse multi-disciplinary teams, tools that teams can use autonomously, enabling scalable governance models and tooling. The benefits are safe, data-driven innovation at scale, better controls and compliances, and better outcomes for individuals and society.

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## Digital Transformations in Taiwanese TV Industry

(Work in Progress)

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### ABSTRACT

In the past, TV was always regarded as an indispensable member of every family. Watching TV programs with the whole family was once one of the key consumer behaviors. However, with the development of technology, the digital wave and the invasion of Over-The-Top (OTT) platforms, consumer behavior has begun to undergo drastic changes. Mobile phones and tablets occupy most of our time. Multi-screens have long become the norm.

According to the "Digital Whirlpool" report published by IMD in 2019: "Due to the impact of digital convergence, digital disruption has already occurred in the media, entertainment, and telecommunications industries. If digital transformation is not carried out in time, the next five may be replaced by other new services". Observe that the number of cable TV subscribers in Taiwan has dropped from 5.23 million in 2017. With the influence of online platforms and online pirated content, it has fallen all the way to the current low of 4.83 million in 2021. Facing the changes in viewers' viewing behaviors and the shift in TV advertising budgets in recent years, various TV stations have also provided solutions and actively transformed from internal thinking to external environments. TV stations such as TVBS, Eastern Broadcasting Company (EBC), Sanli TV and Ctitv have begun their digital transformation.

*Keywords:* E-business, digital transformations, TV industry

### INTRODUCTION

Television is still an important viewing channel for Taiwanese viewers. Even if the number of cable subscribers declines, there are still more than 4 million subscribers. Take EBC as an example, it not only set a new record for broadcasts of the Olympics, the highest ratings in the Tai Tzu-ying's gold medal match reached 18.20, and the total viewership (not repeated) population including the award ceremony reached 5.518 million, accounting for the proportion of Taiwan's population 25.2%; The audience rating of the Golden Melody Awards has also reached an average rating of 4.22, with a total of 3.29 million viewers, which is 308,000 more than last year. The highest rating is when Cao Yawen won the Best Taiwanese Album Award, the viewership population is 13.79 million; In terms of drama, the first broadcast on the TV channel of the girl's development has been a red plate for two consecutive seasons. In the second season, it scored an average viewing rate of 3.59 per minute, and the female audience was 35 years old. By the age of 54, the ratings are as high as 5.46. After being put on the OTT platform, the viewing behaviors are still very impressive.

Whether it's TV or the Internet, consumers' viewing behaviors are constantly changing, but the media market will not disappear. It will only be redefined and divided again and again. TV media is no longer pursuing ratings, content is the essence. The program is the IP, which is operated according to the type and interest preferences. After packaging, it contacts different audiences. The segmentation is for the content of the audience. In the future era of the long tail effect, TV and the Internet will not be a clear competitive relationship, but a cross-platform presentation of mutual cooperation and complementarity. The use of digital transformation is to help content multiply and create new needs, with the audience as the core!

TVBS established a new media department, evaluated its programs and believed that "Women I'm the Biggest" is suitable for designing as an electronic database, developing new business models, establishing exclusive websites and integrating shopping functions.

Develop exclusive program content on the internet, and actively operate social platforms such as Eastern Broadcasting Company's "Buzz", which has launched a series of millions of films such as "10 Troubles of Various Girls", and the total number of views on the YouTube channel of "Buzz" has reached 460 million.

Continue to optimize the function of the official website and develop a mobile APP to provide instant news. Eastern Broadcasting Company also provided instant ticketing information on the APP during the presidential election, and the download volume was as high as 5 in the Android ranking.

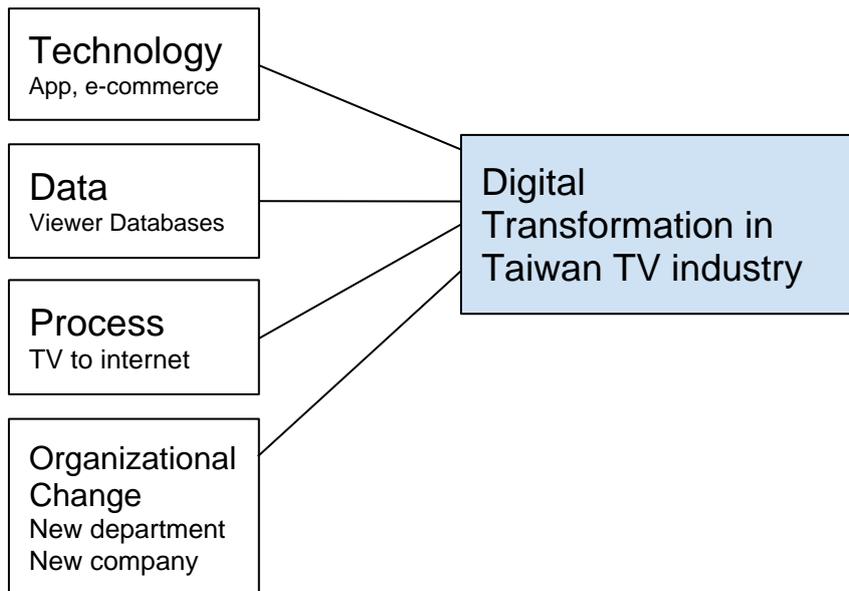
**RESEARCH METHOD**

In order to analyze how companies implement digital transformation strategies. This research adopts multiple cases of world-renowned TV stations analysis. Case analysis is used to collect the relevant topics of the papers, and then surveys are conducted by questionnaire survey methods.

**LITERATURE REVIEW**

**Digital Transformation**

As we all know, digital transformation is trending nowadays. Here are four main areas of digital transformation that need to be noticed. Successful digital transformation requires bringing these four areas together and coordinating a greater range of effort. Data has shown in any one of four interrelated domains — technology, data, process, or organizational change capability — can scuttle an well-conceived transformation.



Source: This study  
Figure 1: Conceptual Framework

*Technology Change*

Traditional pay TV players transform into super-aggregators. Traditional pay TV players have been impacted by OTT audio and video, so they have begun to cooperate with OTT players on a large scale to make OTT audio and video content widely available. They launched on pay-TV platforms, transforming itself into super-aggregators across different content sources. This strategy is generally adopted by many large international cable TV operators. The first operator to conduct hyper-convergence is Virgin media in the UK, which started cooperation with Netflix in 2013. Consumers can use Netflix’s APP and watch Netflix content on Virgin media. Comcast in the U.S. also partnered with Amazon in 2018. Comcast TV users can watch Amazon Prime Video through their set-top box device, the Xfinity X1, and support fast voice search. In addition to supporting each other in set-top box devices, pay-TV and OTT players are also collaborating on content production. In 2018, Liberty Global and Amazon began working together to co-produce the album "The Feed", which will be released in Europe in 2019.

In the past five years, various TV stations, whether active or passive, have started their own digital transformation. With years of experience in content production, the TV stations have constantly revised and combined the characteristics of digital platforms.

1. Oriental Pearl launches digital cross-platform shopping service

Oriental Pearl Tower is the largest cable TV operator in mainland China, and its e-commerce platform “Oriental Shopping” is the most important transformation business within the group. In 2018, its revenue accounted for more than 50% of the group’s revenue. The biggest feature of Oriental Pearl Tower is to copy its old traditional TV shopping model to the Internet, and provide different live and on-demand videos at different time periods in its online mall. In order to reach all consumer groups, Oriental Shopping has launched exclusive applications on various device platforms, including mobile phones, tablets and even Smart TVs, so that consumers can use the phone, mobile phone/tablet/TV APP to download videos.

2. Sky Network

British cable operator Sky Network has recently been actively using AI to improve the consumer experience. For example, in the 2018 broadcast of Prince Harry’s royal wedding, AI facial recognition was used to provide instant introductions to wedding

guests. Sky uses Amazon's Rekognition AI cloud image analysis technology, which can quickly analyze facial image information and display it on the broadcast screen, helping viewers to quickly understand the names of the characters appearing on the screen. This facial recognition technology is also expected to be used in awards ceremonies such as the Oscars and the Golden Globes in the future. In addition, Sky is currently trying to use advanced technologies such as big data and machine learning to achieve automatic content recommendation to increase customers' consumption of TV content. In 2018, Sky introduced Adobe Target's AI system for internal testing, and hopes to successfully apply AI technology to improve customer consumption experience and business performance in the future.

### 3. BBC

BBC has several thousand people working in the Internet area. They have been on the Internet for 10 years, had considerable success and are the major reference- point for information on the Web (Lloret, 2008b). According to Klontzas (2006: 610), BBC Online is «centered on a combination of interactivity, branding and content, BBC Online is ambitious to become a global brand». Hills and Michalis (2000: 491) characterized the BBC Online strategy as a defensive means of expanding audience reach and they conclude that this is mainly due to it being a trusted brand.

### 4. TVBS

At present, TVBS has developed four major IPs under the umbrella of "Women I'm the Biggest", "Food Player", "Earth Golden Line", and "Health 2.0". It has also been awarded the brand trust of Oxford University's "Global Digital News Report" for 4 consecutive years. The first "TVBS News", TVBS is not only IP management team, but also has a large number of professional talents, experts and opinion leaders... etc., established a top TVBS firm, provides in-depth cooperation opportunities in different fields, and builds a high-quality brand Assets and KOL resources continue to create new types of content and transfer entities to online.

In recent years, various online platforms have risen and impacted the traditional media ecology. TVBS is actively carrying out digital transformation and has strong content production capacity and brand power. TVBS News has irreplaceable reach and unique news influence in Taiwan. In addition, actively expand various IP programs, deliver information to the target group in 360 degrees, and start from understanding audience behavior and meeting audience needs, providing audiences with interesting content on different media vehicles, and creating all-round media.

For example, the digital original programs developed by each IP, the biggest "playing beauty research room" by the woman, and the "William Shen Happy Delivery" from the hot shop at 11 o'clock, the video can reach more than 100,000 views in three days. In addition, it has developed a dedicated APP and e-commerce platform. In recent years, it has developed exclusive IP apps. The "TVBS News" APP has 1.3 million downloads.



Figure 2: "Women, I'm the Biggest" TV program websites

Table 1: Digital Transformation from the Technology Perspective

TV stations	Technology Transformation
Oriental Pearl Tower	Oriental Pearl launches digital cross-platform shopping service

TVBS	TVBS has developed four major IPs, and developed a dedicated APP and e-commerce platform
Sky Network	Using AI to improve the consumer experience
Comcast	Comcast in the U.S. also partnered with Amazon
Virgin Media (UK)	cooperate with OTT players such as Netflix

Source: This study

Data Change

1. TVBS

TVBS established a new media department, evaluated its programs and believed that "Women I'm the Biggest" is suitable for designing as an electronic database, developing new business models, establishing an exclusive website and integrating shopping functions into e-commerce models.

TVBS has opened at least 18 original network programs, with several major TV programs leading the way, extending network programs. For example, "Women I'm the Biggest " has " Beauty Room", which has been enlarged from a small theme, such as two episodes of the short program of the actress transforming the room, and the number of views exceeded 2.5 million.

Process Change

Process transformation entails modifying the elements of a business’s processes in order to achieve new goals. Most companies engage in a business process transformation when they require a radical update. Undergoing such a transformation will modernize an organization’s processes, integrate new technology, save money, and better incorporate core systems.

1. Sanli TV

Sanli's "All-Star Games" raised the reality program to the competition level, and opened ticket sales to allow the program to further connect with the audience.

2. EBC

In 2015, Eastern Broadcasting Company TV decided to invest in the digital battlefield, looking for audiences and shaping influence in the online community. In the initial stage, starting with the life and entertainment content preferred by social media at the time to quickly gain popularity and accumulate fans.

In the early stages of digital transformation, the profit model was uncertain, and internally began to review the monetization ability of various types of content, and continued to innovate. Regularly use quantitative data to measure the performance of each platform, analyze traffic trends, evaluate the cost of each content production system, and gradually improve content with revenue monetization capabilities. To ensure that the content of the production system can get the traffic it deserves, and at the same time, it can successfully obtain the advertising campaign. Only by creating content that audiences want to watch , so that you have the opportunity to make further profits.

The influence of pure online media is limited and the development of the platform is difficult to compete with international platforms; Eastern Broadcasting Company is committed to integrating TV and the Internet, combining the popularity and naming of TV channels, as well as the rapid reach of digital social platforms and personalized favorite content , Whether it is daily news and entertainment content, or major international issues and large-scale events, EBC can have a high degree of influence on a broad audience.



▲東森《噪咖》N個女生困擾系列影片

▲東森噪咖YOUTUBE頻道

Figure 3: EBC TV program websites

### Organizational Change

#### 1. CJ Group

South Korea's CJ Group will make its production department independent, and cooperate with other foreign TV stations as a completely independent company.

#### 2. Ctitv

Ctitv News switched to YouTube at the end of 2020. After a year of hard work, it has won the championship in the number of subscribers of news channels on the YouTube platform in Taiwan. 10,000 people, and revenue has repeatedly hit new highs; Ctitv TV won the annual digital transformation award (Partner of Transformation (digital transformation)). The frequency of "Ctitv TV Channel" has grown to 2.61 million subscribers, and the reflection after setting a single-day viewing record of 12 million.

From the ratings of Nielsen to the number of people watching live online now, the audience feedback is more immediate, the news focus that was previously perceived is not necessarily the focus that netizens and audiences want to watch now. New media's data and real-time responses bring the truth, and we have to adjust to the audience's preferences and remain professional in journalism. In the field of digital content, there are no certain laws and standards, and the continuous improvement of algorithms is an endless road, which also leads to the need for quick and flexible adjustments.

Ctitv is the first to interact with fans in real time, listens deeply to fans' ideas and suggestions, launches content that everyone cares about, and constantly improves and adjusts existing content, and plans a website and APP "Ctitv News Network" that combines audio and video content. In the future, new blood will be recruited. The 2021 Ctitv Internet Celebrity Anchor Contest is just the beginning, and Ctitv TV will continue to enter the campus to discover future stars of tomorrow. In addition to doing good content, Ctitv TV is taking a road that no one in Taiwan or even the whole world has gone through. Because of the support and encouragement of fans, Ctitv TV will continue to persevere.

### CONCLUSION

For the media industry, we found that digital transformation can lead to new sources of revenue or even to new business models (e.g., the management of content platforms). TV industries have also embraced the business opportunities offered through digital technologies. Hence, when applying the Digital Transformation Framework to formulate a digital transformation strategy, we will likely need to customize the value creation dimension so it corresponds to the specific requirements of their industries or business models.

Digital transformation is a highly complex, company-wide endeavor. A systematic approach to formulating a digital transformation strategy is crucial for success. Moreover, a firm's first steps toward digital business models are characterized by a high level of uncertainty. To help managers address the challenge more systematically, we have extended previous work on digital transformation strategies through the lessons learned from TV companies in the Taiwan media industry.

This research has identified a set of frameworks that managers responsible for digital transformation have to consider. Digital transformations is also committed to innovating various project placement styles. In addition to the production of industry distribution content, through cooperation with platform technology.

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## Exploring Crowdfunding Success in Cross-Culture Framework

(Work in Progress)

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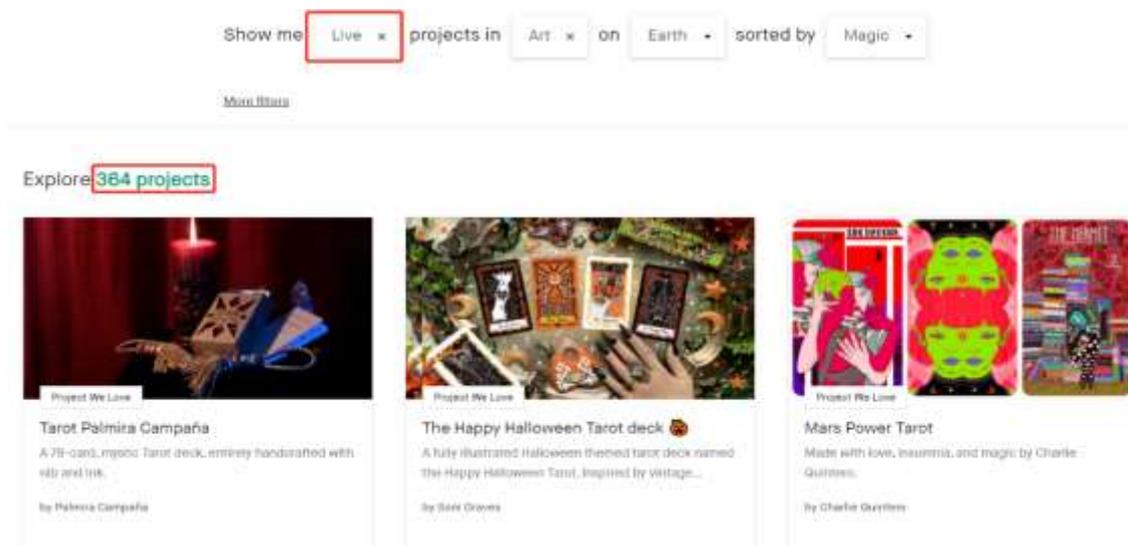
### ABSTRACT

With the rapid development of reward-based crowdfunding, how to make creative projects stand out is of great significance to entrepreneurs and other stakeholders. This study tends to explore the impact of the number of projects within the same category on crowdfunding success and the impact of spatial clustering effect on crowdfunding success. We draw upon a sample of 11,576,590 daily observations of 331,104 projects from Kickstarter, finding a negative association exists between the number of projects within the same category (NPSC) and crowdfunding success, which means that the concurrent impact of the number of projects within the same category (NPSC) on crowdfunding success displays the much larger competitive effects. The preliminary findings are discussed, and it is hoped that this work can be used to explore the key factors influencing the fundraising success of reward-based crowdfunding projects.

*Keywords:* Projects within the same category, crowdfunding success, national cultural values

### INTRODUCTION

Crowdfunding has been a popular and effective way to help entrepreneurs raise funds for their innovative ideas on a digital platform referring to a website or organization operated by startups or industry incumbents, supporting projects seeking investment and investors with funds together (Dushnitsky *et al.*, 2016). For example, Kickstarter, the leading reward-based crowdfunding platform, has raised more than \$5440 million for supporting 209,648 numerous creative ideas of various categories off the ground until October 12, 2021, with a crowdfunding success rate of nearly 39.16% (Kickstarter, 2021). It shows that there is still about 60 percent of projects struggling to meet their funding goals and attempting to explore the hints to enhance their crowdfunding success, which is defined here as the amount of money raised by crowdfunding projects that meet or exceed the pre-determined fundraising goals (Wang *et al.*, 2018). Therefore, to promote crowdfunding success, previous studies have explored the factors influencing the success of reward-based crowdfunding projects, including some project-level signals, such as linguistic style of crowdfunding pitches (Parhankangas & Renko, 2017), comments from backers (Petitjean, 2018), and also entrepreneur-level factors such as narcissism (Butticè & Rovelli, 2020) and successful crowdfunding experience (Koch & Siering, 2019). Besides, the impact of projects and founder features (Lagazio & Querci, 2018; Skirnevskiy *et al.*, 2017) and pledging environment (Koch & Siering, 2019; Mollick, 2014) have also been verified to have effects on crowdfunding success.



Source: Kickstarter Platform  
Figure 1: NPSC presented in Kickstarter platform.

However, there is limited understanding of the effect of the number of projects within the same category on the funding success of the projects. The number of projects within the same category (NPSC) refers to projects that have the same or similar attributes and are classified as the same category in the online crowdfunding platform, as shown in Figure 1 below. For example, in the art category, the corresponding NPSC for a focal project is 364. Investors can filter live projects within the same category by category in the online crowdfunding platform.

In addition, considering that the cultural orientation of different countries may affect the investment decisions of investors in crowdfunding, this article aims to explore the impact of NPSC on crowdfunding success and explore the differences in its influence between countries with different cultural values.

We collect and analyze data of 331,104 crowdfunding projects and 11,576,590 records of daily pledges from Kickstarter. We use logistic regression to explore the influence of NPSC on crowdfunding success. We adopt spatial measurement methods and use cultural dimensions of power distance (PDI), individualism/collectivism (IDV), masculinization/feminization (MAS), and uncertainty avoidance (UAI) to construct a spatial weight matrix to determine the spatial measurement model. Our findings primarily suggest that the NPSC has a significant negative impact on the crowdfunding success of the focal project, indicating the negative competitive effect of the project market crowding outweighs the positive spillover effect.

## LITERATURE REVIEW

### Crowdfunding Success

Scholars have studied the antecedents of crowdfunding success from project features, founder-related factors, and the pledging process. Lagazio and Querci (2018) find that entrepreneurs can communicate with investors and promote fundraising activities via pictures and pitch videos. Projects in different categories with sustainability orientation will affect the ability of entrepreneurs to acquire financial resources from supporters differently (Calic & Mosakowski, 2016). Such literature considers the number of live projects as control variables without probing the effect of NPSC thoroughly. Another group of scholars has studied founder features. For example, Courtney *et al.* (2017) suggest that the founder's previous successful crowdfunding experience has a positive impact on the possibility of crowdfunding success for the following crowdfunding project. Other studies examined the effects of factors affecting the pledging process. For instance, Wang *et al.* (2018) emphasize the importance of founder-backer interaction in crowdfunding success. These studies consider the effects of various factors for crowdfunding success but neglect the number of homogeneous competitors (i.e., projects within the same category), which could play an important role in crowdfunding success.

### Number of Competitors

A question that has aroused much attention in the field of marketing and economics is how the number of competitors and market outcomes are associated. Prior studies have explained the impact of the number of competitors. For example, Grewal and Lindsey-Mullikin (2006) provide evidence that when the number of competitors increases, consumers are less likely to engage in additional searching in the online shopping context. Search literature regards the number of competitors as a moderator to explore the impact of increased competition intensity on consumer search behavior and product price (Janssen & Moraga Gonzalez, 2004).

### Indirect Network Externality

The indirect network externality is manifested as the increase in the use of a certain product will affect the price and sales of similar complementary products (Podoyntsyna *et al.*, 2013). The indirect effects of network externalities also exist in the online crowdfunding context. The small number of crowdfunding projects receiving large amounts of funding have positive spillover effects on other projects in the platform by attracting more potential investors, and the magnitude and direction of such network externalities varied according to the project category (Liu *et al.*, 2015). Our study extends the findings of previous studies by expanding the sample size to verify and explore the indirect network externalities which exist in different clusters of crowdfunding projects.

### Search Cost and Consumption Intention

Most existing literature reveals how search costs affect consumers' behavior. For example, Wang and Sahin (2018) incorporate search cost into consumer choice behavior and investigate a consider-then-choose choice model. Consumers search for information in the consideration stage to eliminate uncertainty, and then they choose the one with the highest utility. The increasing search costs in online markets may have strong adverse effects on consumer welfare, and online markets should formulate and introduce policies to reduce consumer search costs and further stimulate search and entry. However, there are few studies referred the search cost of the investors in the crowdfunding platform context. To fill this gap, from the perspective of NPSC, this research enriches the mechanism of search cost theory in the context of online crowdfunding.

### National Cultural Values

National cultural values are a series of beliefs and values displayed by people in a country, and it is also the product of long-term socialization. The cultural dimension explored by Hofstede is widely used in empirical research. From the perspective of basic value needs, Hofstede has determined four value dimensions (power distance, individualism/collectivism, masculinization/feminization, and uncertainty avoidance) by investigating and studying the values of 40 countries. The

Hofstede cultural dimension is generally considered to be a representative dimension that can reflect the differences in the traditional culture of various countries and a value dimension that focuses on national culture.

Power distance describes the acceptance of unequal distribution of power among people in a country or an organization (Hofstede, 1983). In countries with a high-level power distance, people tend to accept a hierarchical structure with large gaps. On the contrary, most people expect power to be distributed as equally as possible. Individualism/collectivism distinguishes the importance of individuals or groups in national cultural values. Countries with individualistic cultures pay more attention to the needs, interests of individuals and their immediate family members, while countries with collectivist cultures pay more attention to collective needs and interests (Hofstede *et al.*, 2005). Masculinization/feminization emphasizes the degree to which masculinity values dominate the society or group. Highly masculine groups emphasize the degree of attention to others, the quality of work and life, the qualities of humility, cooperation, and caring for others (Hofstede *et al.*, 2005). Uncertainty avoidance is defined as the way members of society deal with uncertainty and risks (Hofstede, 1983). Groups with higher uncertainty avoidance are more cautious, unwilling to take risks, and do not violate social and cultural norms. Groups with lower uncertainty avoidance are more likely to accept decisions with certain risks (Hofstede, 1983). This article will use the Hofstede cultural dimension to construct a cross-culture framework and explain the influence of NPSC on crowdfunding success.

## DATA AND METHOD

### Data

To investigate the cross-country differences in the impact of NPSC on crowdfunding success, we collected data about crowdfunding projects launched on Kickstarter, the most well-known and largest reward-based online crowdfunding platform in the United States, which follows an “all or nothing” pattern. Kickstarter is greatly appropriate for the aim of this research as the scale of this platform is large enough, and project classification is detailed (e.g., Arts, Film, Games, and Music). A sufficient sample size allows us to explore the factors that affect crowdfunding success in the segmented market of the same project category. Data on crowdfunding projects launched on Kickstarter has already been used in a number of studies in the field of online crowdfunding (Burtch *et al.*, 2018). At the same time, we obtained data on the Hofstede cultural dimensions (power distance, individualism/collectivism, masculinization/feminization, uncertainty avoidance) of the countries covered by the sample from clearlycultural.com. After merging different project information data, we assembled a panel data comprised 11,570,590 observations of 331,104 crowdfunding projects spanning from 2009 to 2018 year and covers all categories classified by the Kickstarter platform.

### Variables

#### Dependent variable

Our target outcome is fundraising success. Thus, we construct the dependent variable *CrowdfundingSuccess*, which has been used in previous studies (Butticè & Rovelli 2020; Yuan *et al.*, 2016). *CrowdfundingSuccess* is an indicator variable equal to 1 if the crowdfunding project reaches the funding goal within the funding period. Otherwise, the value is 0.

#### Independent variable

For the explanatory variable, *the number of projects within the same category (NPSC)* is used to measure the number of other live crowdfunding projects within the same category for a focal project.

### Empirical Model and Specification

As discussed above, we extend our analyses for the impact of NPSC on crowdfunding success for a focal project, and it is appropriate to employ a baseline logistic regression model to examine the effects. Our complete model specification is given by:

$$CrowdfundingSuccess_{it} = \alpha + \delta * NPSC_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

*CrowdfundingSuccess<sub>it</sub>* is a dummy variable. It equals 1 if the focal crowdfunding project *i* reaches the funding goal on day *t*, and otherwise, the value is zero. *NPSC<sub>it</sub>* represents the number of live crowdfunding projects within the same category for the focal project *i* that exist in the crowdfunding market on day *t*. The parameter  $\delta$  is coefficient.  $\mu_i$  and  $\lambda_t$  represent project fixed effects and day fixed effects.  $\varepsilon_{it}$  denotes the error term. We use robust standard errors clustered at the projects level to deal with potential issues of heteroscedasticity.

Based on different entrepreneurial resource endowments, economic conditions, and cultural values, the development of reward-based crowdfunding in various countries is generally uneven, but the development of neighboring countries is prone to the convergence of crowdfunding results, resulting in spatial interaction between crowdfunding activities. By introducing spatial effects into the baseline model, according to the different impact methods of the spatial items, we constructed the following three spatial panel models containing the relationship between NPSC and crowdfunding success.

The spatial lag model (SLM) adds the spatial lag of the explained variable to the classic econometric model, indicating that crowdfunding results of the research unit are not only affected by the local explanatory variable but also depend on crowdfunding results in its neighboring regions. The formula is as follows:

$$CrowdfundingSuccess_{it} = \alpha + \rho \sum_{j=1}^{23} w_{ij} CrowdfundingSuccess_{jt} + \delta NPSC_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \varepsilon_{it} \in N(0, \sigma^2 I_n) \quad (2)$$

$w_{ij}$  is the element of row  $i$ , and column  $j$  of the standardized  $N \times N$  dimensional spatial weight matrix  $w$ .  $\mu_i$  and  $\lambda_t$  represent project fixed effects and time fixed effects.  $w_{ij} CrowdfundingSuccess_{jt}$  refers to the spatial lag term of the explained variable,  $\rho$  is the spatial lag autoregressive coefficient, representing the magnitude and direction of the spatial spillover effect,  $\mu_i$  and  $\lambda_t$  represent project fixed effects and time fixed effects.

The spatial error model (SEM) adds the neglected spatial error term to the classic econometrics model, which means that the crowdfunding result of the research unit depends on the observed set of local features and the spatial error term of the neighboring research unit. The formula is as follows:

$$CrowdfundingSuccess_{it} = \alpha + \delta NPSC_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \varepsilon_{it} = \nu \sum_{j=1}^{23} w_{ij} \varepsilon_{jt} + \varphi_{it}, \varphi_{it} \in N(0, \sigma^2 I_n) \quad (3)$$

$\nu$  is the spatial residual autocorrelation coefficient, and the other variables have the same meaning as above.

The spatial Durbin model (SDM) is a synthesis of the above two spatial panel models. It is believed that there is a spatial correlation between the project crowdfunding results of the research unit and the variables in the neighboring regions. The formula is as follows:

$$CrowdfundingSuccess_{it} = \alpha + \rho \sum_{j=1}^{23} w_{ij} CrowdfundingSuccess_{jt} + \delta NPSC_{it} + \theta \sum_{j=1}^{24} w_{ij} NPSC_{jt} + \mu_i + \lambda_t + \varepsilon_{it}, \varepsilon_{it} \in N(0, \sigma^2 I_n) \quad (4)$$

$\theta$  is the elastic coefficient of the lag in the independent variable space, and the other variables have the same meaning as above.

### PRELIMINARY FINDINGS

We formally conduct our analyses by using a panel logit framework to evaluate the effect of NPSC on crowdfunding success. Our regression estimates suggest that the more projects within the same category existed in the online crowdfunding market, the lower the probability of crowdfunding success. That is, market crowding within the same categories is not conducive to successful crowdfunding projects. The competitive effect among projects within the same category is greater than the positive spillover effect, which is in line with the 60% failure rate of the failure rate of project fundraising across the platform (Kickstarter, 2021).

The next steps for this research are to conduct a series of analytical processes, including constructing a spatial measurement model based on formula (1), analyzing the results of spatial econometric analysis, and results of sub-sample regression. By conducting the analytical processes, we can find the role of cultural differences in the relationship between NPSC and crowdfunding success.

### ACKNOWLEDGMENT

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## **Hospital as a Sheltered Workshop to Improve the Disabled People's Resilience with Working Capability and to Re-join Our Society**

*(Work in Progress)*

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### **ABSTRACT**

The hospital with sheltered workshops can provide both medical care and vocational training that help the disabled patients improve not just their health but also re-build their confidence to re-join our society. The fundamental support for the sheltered workshop is legally the People with Disabilities Rights Protection Act and medically the hospital institutions. This case is about how we can learn from the Bei-tou hospital of Tri-Service General Hospital, which has been contributed to the sheltered workshop for their patients by cooperating with the Labor Bureau of Taipei City Government since April of 2012.

*Keywords:* Sheltered workshop, disabilities right protection act, post-traumatic stress disorder,

### **INTRODUCTION**

The hospital with sheltered workshops can provide both medical care and vocational training that help the disabled patients improve not just their health but also re-build their confidence to re-join our society. The term sheltered workshop refers to an organization or environment that employs people with disabilities separately from others, usually with exemptions from labor standards, including but not limited to the absence of minimum wage requirements. This case study tends to demonstrate how we can learn from the Bei-tou hospital of Tri-Service General Hospital, which has been contributed to the sheltered workshop for their patients by cooperating with the Labor Bureau of Taipei City Government since April of 2012.

### **REAL WORLD DISASTERS**

Life is not easy for each individual, particularly for disabled people who suffered physical damage and mental trauma. For the past six years, it happened the tragedies that killed and injured hundreds of people, such as the aircraft crash in Kee-long river in Taipei city that killed 43 people in 2015, the Ba-xien Paradise powder explosion in New Taipei city that injured 499 people in 2015, the train crash of Puyuma in I-lan county that killed 18 people in 2018 and also the train crash of Taroko in Hualien county that killed 49 people in 2021. Such kind of adversity, misfortune, and tragedy caused not only serious casualties tolls but also left alive people to disable, and it takes a long way to go to restore from the post-traumatic stress disorder, PTSD.

On Friday, April 2, this year, an express train of Taroko running fast along the east coast of Taiwan, unfortunately, derailed after colliding with a crane truck that was just on tracks. Forty-nine people died in the accident of human error, while hundreds of others in this train were treated for injuries. Many of the victims of the crash were traveling to Hualien and Taitung to pay respect to their ancestors during the Tomb-Sweeping holiday

### **HOPITAL HELPS RE-JOINING OUR SOCIETY**

Medical cares are so important to restore our patients physically and mentally. Together with the Department of Labor, Taipei City Government, the Bei-tou hospital of Tri-Service General Hospital have been performing the sheltered workshop for the disabled people since 2016 and had trained them with medical cares and also to live their lives on their own at the workshop. Finally the workshop of Bei-tou hospital also help the improved disabled people of its workshop to apply working opportunities outside, and there were 2 of the 3 applicants from 2017 to 2019 successfully got the offer letter respectively issued by a shoe manufacture & sales company as a graphic designer and the other by Melaleuca Taiwan as a sales dealer.

Although the numbers of working out of the sheltered workshop is not many, the disabled people are still working with good cares, no matter cleaning, cooking or fixing coffee, and living on their own in the hospital surroundings, in which we share the same society.

In addition to the Labor Department of Taipei City Government, the sheltered workshops also need the other governmental resources to support such as the Social Welfare Department of Taipei City Government to provide financial sponsorship like working incentive, long-term psychological consultation program, and so on. The other cities and countries are more or less the same to learn from Taipei and take care of them.

**CASE BACKGROUNDS**

Besides, Tri-Service General Hospital Bei-tou Branch has been doing further and more like a sheltered workshop by providing their patients with a regular vocational class consisting of mechanical training, sales and booking skills as well as psychological consultation at the geothermal valley shop located in Bei-tou hot spring area, the business and working space supplied by Taipei city government and run by the Tri-Service General Hospital Bei-tou Branch.

Table 1: Professional of Tri-Service General Hospital Bei-tou Branch, 2020

Type	Doctor	Nurse	Pharm <sup>1</sup>	Psych <sup>2</sup>	SW <sup>3</sup>	OT <sup>4</sup>	MT <sup>5</sup>	GA <sup>6</sup>
Personnel	47	166	14	10	8	12	6	96

Note: 1= pharmacist, 2= psychologist, 3= social work, 4= occupational training, 5= medical technology, 6= general affairs.

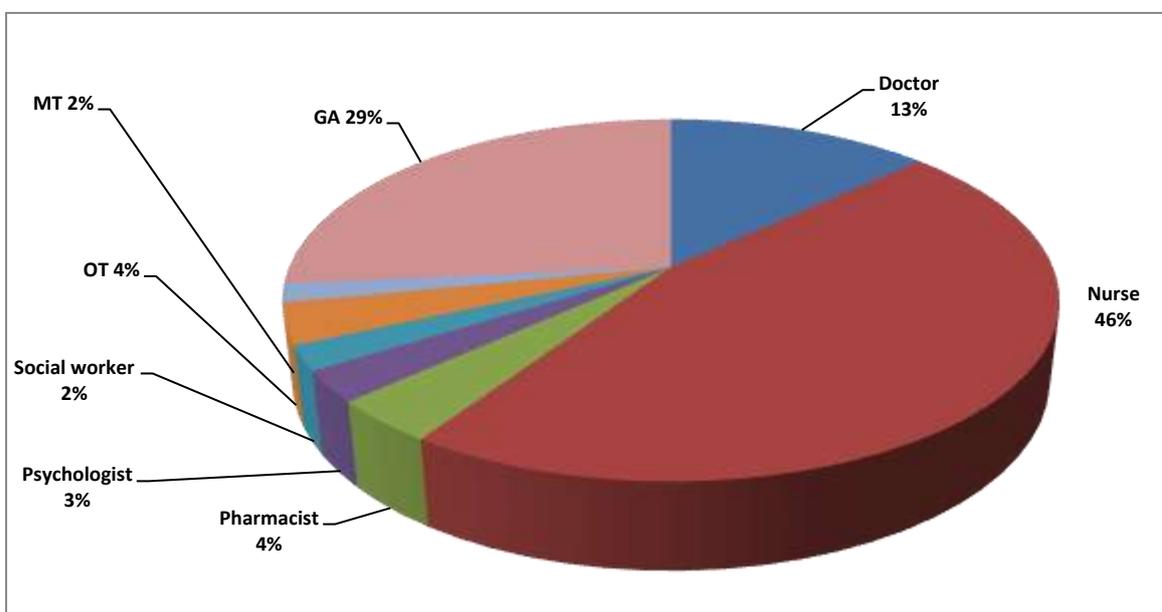


Figure 1: Pie of Professional of Tri-Service General Hospital Bei-tou Branch, 2020

With medical care and vocational training, disabled patients can not only improve their health but also rebuild their confidence to re-join our society. This is what we want to share that the Bei-tou hospital of Tri-Service General Hospital has been contributed to the sheltered workshop for their patients by cooperating with the Labor Bureau of Taipei City Government since April of 2012.

The fundamental support for the sheltered workshop is legally the People with Disabilities Rights Protection Act and medically the hospital institutions. For more than one year, we have been fighting against the pandemic, and we can understand those who ran into adversity, misfortune, and tragedy.

Accordingly, the sheltered workshop, take this geothermal valley shop, for example, is very much in need, and the key success factors are the “walk to talk” enforcement and collaboration between the Bei-tou hospital of Tri-Service General Hospital and the Labor Bureau of Taipei City Government.

**PROPOSED METHODOLOGY**

The next step of this study is to make certain focus groups, such as the sheltered professional, the family or relatives of the disabled people, and the companies that provide working opportunities to them. And then to research further by case study methodology to collect more information and to introduce a better procedure and a possible bridge between the sheltered workshop and the real occupational workplace.

By applying the sub-information analysis and the indepth interviews with the professionals on medical care, vocational training, teaching strategy and social adaptation, we are to construct a platform among hospital, industry and the governmental agencies ( labor Department of Labor and Department of Social Welfare) in order to streamline the process and evaluate the performance.

Finally we decide to use Grounded Theory to prove and find out the key success factors that how the disabled people overcome the PTSD and re-join our society.

### CONCLUSION

This study suggests that the hospital with sheltered workshops can provide both medical care and vocational training to help the disabled patients improve not just their health but also re-build their confidence to re-join our society. We have provided a preliminary case backgrounds of Bei-tou hospital of Tri-Service General Hospital, which has been contributed to the sheltered workshop for their patients by cooperating with the Labor Bureau of Taipei City Government since April of 2012.

Currently, we are still in the preliminary stage of the cases study. In the next, we will conduct more literature search on how hospitals, acts as the sheltered workshop, help their patients re-join the society. Moreover, we will conduct more interviews with the senior, middle, and operational levels of managers in the case hospital in order to identify how they train the patients, performe the relevant processes, and evaluate the training performance. The grounded theory approach will be also conducted in order to identify the critical success factors of re-joining patients to our society.

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## How Does Word of Mouth from Different Components Systems Influence Product Sales differently?

(Work in Progress)

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### ABSTRACT

Online word-of-mouth (WOM) has become an important reference for customers' online purchase decisions. However, current studies ignore the various effects of WOM in different components, i.e., online reviews and the replies in the question and answer (Q &A) discussion area. To fill such a research gap, this study explores the relationship between WOM in two different forms and product sales. We measure the semantic features and thematic consistency of two forms of WOM and product sales. The findings show that the review component and Q&A component differ significantly in terms of quantity and content richness, with the review component being richer and more voluminous and the Q&A section having less content and relatively less quantity in comparison. Besides, the OLS results suggest that topic consistency has a negative impact on product sales, while the richness characteristics of both have a positive impact on product sales, and that the content richness of the Q&A component has a greater impact on sales than the review component.

*Keywords:* Online review components, Q&A components, user-generated content text analysis, semantic features, topic consistency

### INTRODUCTION

Online shopping has developed rapidly in the background of COVID-19, and the research on factors affecting product sales is getting more and more important for the online business (Wang, 2020). Word-of-mouth (WOM), the feedback, recommendations, or opinions from consumers' family, friends, sellers, or from others who have purchased the product or service (Murray, 1991), has been one of the most effective factors in influencing consumers (Helm, 2007). WOM shows its impact on product sales in various platforms, including Amazon, online book reviews, and box office revenues, and these studies validate the direct link between consumer reviews and sales of products.

More and more businesses are recognizing the importance of online WOM and encouraging consumers to share their buying experiences and engage with others in order to gain more potential customers. WOM is aggregated in such a process of interaction among the experienced consumers who have already purchased, potential consumers, and sellers. In Figure 1, it is shown that the WOM from online reviews and also Q&A forums in Qunar, one of the most popular online traveling agencies in China. The communication forms and contents are different and form different WOM in these two components systems.

The Q&A area is an area for customers to discuss issues, so it is a "many-to-many" situation; in contrast, reviews are a "one-to-many" form because many consumers can make judgments about products by referring to a specific review, but the number of discussions generated by reviews is relatively small compared to the number of responses under Q&A, and therefore the aggregation level is low. According to the consumer decision-making process (Colicev *et al.*, 2017), consumers are able to identify the general characteristics of a product with reference to many-to-many WOM during the purchase process and then make judgments and choices in combination with many-to-many WOM and one-to-many WOM.

Although multiple WOM sources have been developed, applied, and studied, it is still found that the information in the online review and Q&A forums encounter diverse situations. The merchants seem to prefer to reply with online reviews, ignoring the question in Q&A forums where have less information. Even in academia, most of the current studies focus only on the online reviews and still lack probing the WOM from Q&A forums considering with different information granularity. Therefore, in order to fill the research gaps, we hope to address the following two research questions in this study:

**RQ1** How do the impacts of WOM from review systems and Q&A forums on sales vary?

**RQ2** What are the detailed differences in WOM characteristics (emotion, quantity, richness) between WOM from review systems and Q&A forums?

This paper explores the differences in the impact of different presentation forms of online word-of-mouth on consumer decision-making at both coarse-grained and granular levels, which contribute to the WOM research. In practice, the study not only guides merchants to develop effective marketing strategies but also helps consumers to identify informative review information and also helps potential consumers to reduce information overload.

The screenshot displays two sections of a hotel's online presence. The top section, titled 'WOM in Review component', shows a review for a hotel with a 4.3-point rating and 97% recommendation. The review text is: '# Bathroom clean #room clean #service attitude is very good #safe and assured'. The reviewer, 'ya', has 42 reviews and has been to 16 cities. The review includes six photos of the hotel's interior. The bottom section, titled 'WOM in Q&A component', shows a question 'Can you issue a ticket?' and an answer 'Can. Online prepaid orders will be issued by the website. Payment orders at the front desk will be invoiced by the hotel.' The question was asked by 'wmer49...' and the answer by 'qunarppb\_1564799658' on December 12, 2019.

Figure 1: The different WOM from reviews system and Q&A forum.

### REVIEW OF EXISTING STUDIES

There are numerous studies on online reviews and consumer decision-making, from the early days of studying price and volume (Liu, 2006; Marchand *et al.*, 2017; Colicev *et al.*, 2017; Xie & Lee, 2015), which have gradually deepened to emotional value (Tellis *et al.*, 2019), language features (Bastos & Moore, 2021; Packard & Berger, 2020; Tellis *et al.*, 2019; Packard *et al.*, 2018), and other detailed levels of exploration. However, these previous studies at the detailed level either focus on laboratory settings or originate from manipulated data, lacking the support of actual purchase environment data (Bastos & Moore, 2021; Packard & Berger, 2020). Besides, the macro-level of operations also works (e.g., volume and valence, (Colicev *et al.*, 2017)). Consumers make purchase decisions by examining not only information about the accessibility of goods but also considering their own judgments when given diagnostic information (Colicev *et al.*, 2017).

As word-of-mouth has been explored, more and more scholars have expanded on the detailed characteristics (e.g., price, quantity, etc.) studies. Chevalier and Mayzlin (2006) argue that consumers do not rely on the number of reviews but place more importance on the quality of the information in online reviews, such as emotional disposition (Tellis *et al.*, 2019), content richness (Nguyen & Chaudhuri, 2018), and content substantiality (Bastos & Moore, 2021). However, detailed level research is less operational due to the difficulty of directly guiding marketing strategy adjustments, leading more WOM research to start combining with tangible micro information (e.g., topic similarity, linguistic features, etc., Aghakhani *et al.*, 2020) in order to better guide business practices.

In addition to this, other related consumer engagement behaviors may also have different impacts on value creation, Dhaoui and Webster (2021) by examining consumer engagement behaviors outside of value creation on FBP (endorsement, feedback, recommendation, conversation, and consensus), demonstrating that each of these behaviors is related to each other and that consumer decisions are influenced not only by these behaviors but also by other consumers. Although studies have been conducted to explore the difference between forums and reviews in the sales process and there is a large literature on the impact of word-of-mouth, few studies have combined the two, which is important for enriching merchants' marketing decision strategies and addressing consumers' information redundancy, and this study is expected to fill this research gap.

## RESEARCH FRAMEWORK

There are four stages of the sales funnel in the decision process, including awareness, interest, decision, and action (AIDA)<sup>1</sup>, and in the above-mentioned consumer decision process, we choose the consumer behavior in the decision stage as the main object of study. From the perspective of information acquisition, consumers in the decision stage are driven by the persuasive mechanism of the central path and are concerned with both the diagnostic and accessibility of information. Therefore, it is at the decision stage that consumers are more likely to refer to the comments and Q&A sections and make their choices and judgments (Petty & Cacioppo, 1986; Feldman & Lynch, 1988).

Differences in information paths and psychological mechanisms make the impact of word-of-mouth in the comment and Q&A sections both similar and different. We refer to Yang's (2021) framework and propose a research framework in which quantity, length, and thematic similarity synergistically influence consumer decisions. The framework is presented in Figure 2.

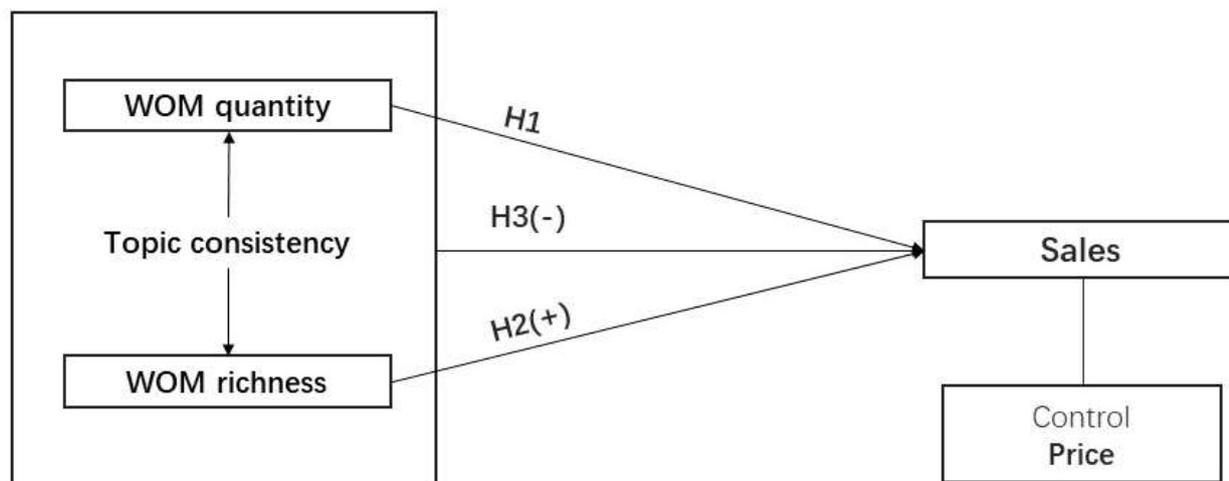


Figure 2: the conceptual framework of the study.

### WOM Quantity

There has been extensive research that proves that the number of consumer reviews positively affects purchase, Marchand's (2017) study explores the impact of the number of consumer reviews and Twitter WOM on new products at different stages, the results show that before the release of a new product the number of consumer reviews and Twitter WOM quantity had a significant positive impact on product sales, while when the product was released, the impact of Twitter word-of-mouth quantity gradually diminished while the impact of consumer review quantity gradually increased (Marchand *et al.*, 2017). In addition, products with a high number of reviews are also more likely to be favored by platforms, receive front-page recommendations, and gain greater exposure (Colicev *et al.*, 2017).

Increasingly, platforms are enhancing their positive impact on product performance by aggregating the number of reviews, displaying the number of reviews on their web pages to guide potential consumers to generate interest in the product and reduce the risk of purchase (Roselius *et al.*, 1971), in contrast, the Q&A section often appears as a supplement to the content of the review section and does not list the number of questions and answers, which has a very limited, and therefore the following hypothesis is proposed.

**H1** *Of the Q&A and review systems, only the volume of review systems has a positive effect on sales; the volume of Q&A sections does not affect sales.*

### WOM Richness

Previous research has found that rich information provides consumers with more functional, value-based information (Nguyen & Chaudhuri, 2018). This information about the experience can stimulate a sense of engagement and meaningfulness in consumers, leading to a higher degree of materiality, which makes it easier to make a purchase decision or other value-creating behavior (Bastos & Moore, 2021). In addition, length reflects the involvement of the reviewer, and when reviewer involvement

<sup>1</sup> <https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/the-consumer-decision-journey>

<https://www.the-future-of-commerce.com/2016/09/26/definition-consumer-journey/>

is higher, other consumers can obtain more decision information from the reviewer (Pan & Zhang, 2011), and this useful information can help consumers in information filtering and even in following behavior (Aghakhani, 2020).

Consumer reviews and Q&A formats differ in the form in which content is presented. Generally, merchants encourage consumers to participate in reviews through monetary incentives or platform incentives but give fewer rewards for Q&A on goods, so reviews are both altruistic and self-serving, while answers in Q&A sections are more likely to be an altruistic act (Tellis *et al.*, 2019), a mechanism that leads to a certain number of false or invalid comments in review content, as opposed to Q&A section content, which is less useful in the minds of consumers. Therefore, the following hypothesis is proposed:

*H2 WOM richness (length) has a positive impact on sales, with the length of ANSWERS having a greater impact than reviews*

### Topic consistency

According to information overload theory (Yang *et al.*, 2021; Luo *et al.*, 2013), the increased consistency between merchant responses and consumer review topics reduces the perceived information overload and increases consumers' motivation to process information. Besides, the ELM (Elaboration Likelihood Model) indicates consumers' motivation to process information determines their accuracy in processing information. That is, topic consistency improves the degree to which consumers process information about the content of a review, enabling them to more accurately grasp the true content (Guo & Zhou, 2016). Consumers' scrutiny of the product makes them more cautious about the decision-making process and more willing to refer to the negative reviews in which they criticize the product, thus making fewer purchases.

The consequent result is that consumer endorsement of negative information in review messages increases when the degree of consistency increases, as demonstrated by Herhausen (2019), who showed that linguistic style matching promotes (negative) word-of-mouth communication and Moore's (2017) study, which further demonstrates that linguistic imitation in forums reduces engagement behavior, especially in high-priced risk situations. Consumers process information more profoundly (Petty & Cacioppo, 2012), and negative information has a greater impact on consumers' decisions. Based on this, we propose hypothesis 3

*H3 Review-Answer topic consistency shows a negative effect on sales*

## EMPIRICAL ANALYSIS

### Sample and Data Sources

In the process of obtaining the data, the JD Mall e-commerce platform was selected as the sample source.<sup>2</sup>In JD, based on the classification of the webpage identified the retailing of refrigerators as the context of the study, this is because refrigerators, like large appliances, have a high risk of the purchase, and consumers tend to obtain more useful information to help complete the purchase behavior during the purchase process ((Tellis *et al.*, 2019). And the products are selected according to the following principles: a. have self-owned stores in JD platform; b. are listed companies. JD self-operated ensures uniformity of logistics and delivery, while corporate information of listed companies is more accessible (Kushwaha *et al.*, 2013).

### Measurement

Number and length were measured with reference to existing literature, and the total number and length were counted separately. (Colicev *et al.*, 2017; Marchand *et al.*, 2017) Next, refer to Yang's (2021) method to measure the topic similarity. First, the JiebaR word splitting tool was applied to Chinese word splitting, and the top 50 keywords with the highest frequency in the comment section and the question and answer section for each product were extracted using the TF-IDF method, respectively, and then refer to Niwattanakul's (2013) study using Jaccard similarity method to calculate topic consistency. Regarding the measurement of sales, we use a logarithmic approach to the sales ranking to measure sales (Li *et al.*, 2020).

### Analysis of Results

This paper adopts Stata 16.0 statistical software as the analysis tool, uses JD official backend data plug-in "business reference" for statistical analysis, uses Python and Excel tools for content processing, and uses general linear regression method to test the research hypothesis, and the OLS model is as follows:

$$\ln\_rk = \beta_0 + \beta_1 \ln\_rv + \beta_2 \ln\_ans + \beta_3 \text{num\_rv} + \beta_4 \text{num\_ans} + \beta_5 \text{sim\_rv\_ans} + \beta_6 \text{price} + \varepsilon \quad (1)$$

Where *ln\_rv* and *ln\_ans* represent the length of the comment and the length of the answer respectively; *num\_rv* and *num\_ans* respectively represent the number of comments and the number of answers; *sim\_rv\_ans* represents the similarity between comments and answers, reflecting the consistency of comments and answers. Besides, *price* is regarded as a control variable,  $\beta_0$  is the constant term,  $\varepsilon$  is the error term.

<sup>2</sup> <https://www.jd.com/>

According to Xia's (2014) conceptual framework, communication channels are divided into one-to-many and many-to-many forms of social aggregation, and we consider review systems as one-to-many and Q&A as many-to-many forms. To verify the difference in impact between the two, we measure content characteristics, i.e., content richness (length) and volume (volumn), variables that are considered to be important for value-creating behavior that can be measured and compared by textual analysis, and therefore reflect the differences in impact across social aggregation formats. We randomly selected 10 of the 20-star products (top ones) as a small sample set for our study, which was proved to be reliable in using a small sample as the prediction. (Colicev et al., 2017; Marchand et al., 2017; Aghakhani, N., 2018)

The ordinary linear regression was used to test whether there was a linear relationship between the number and length of comments in the comments and Q&A sections and the dependent variable. The results are shown in Table 1.

Table1: Preliminary Linear Regression Results.

ln_rk	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
len_rv	0.0257939	0.001545	16.7	0.000	0.0208776	0.0307101
len_ans	0.0589199	0.001145	51.48	0.000	0.0552774	0.0625624
num_rv	-9.00E-08	4.33E-07	-0.21	0.849	-1.47E-06	1.29E-06
num_ans	0.0000207	2.66E-05	0.78	0.493	-0.0000639	0.0001052
sim_rv_ans	-2.204909	0.422981	-5.21	0.014	-3.551024	-0.8587937
price	-0.0000976	1.53E-05	-6.4	0.008	-0.0001461	-0.000049
_cons	0.2237962	0.205854	1.09	0.357	-0.4313234	0.8789157

The results show that although different forms of social interaction have an impact on sales, the impact of the presented comment characteristics on sales varies, with the length of comments having a smaller impact on the logarithm of the ranking of sales ( $t=2.79$ ,  $p=0.049$ ) than the length of responses on the ranking of sales ( $t=8.74$ ,  $p=0.001$ ), and that not all characteristics of comments in the context of online shopping platforms were supported, and the length of questions, comments and the cumulative number of responses did not show a significant effect on sales. Overall, the two types of interactions presented by comments and Q&As had different effects on sales, with the length of answers having a greater effect on sales if the length of responses to both answers and comments was increased by one unit.

However, the results show that the number of reviews and Q&As does not have a significant effect on product sales, probably because product purchases belong to the decision stage when consumers are most motivated and capable of information processing and rely to a greater extent on diagnostic information, while quantity, an accessible piece of information, is less informative and therefore less dependent and has minimal impact on the direct impact of consumer decisions. (Colicev *et al.* 2017; Petty & Cacioppo 1986, 2012; Feldman & Lynch 1988).

We also conducted the word cloud picture of comments in Figure 3. We found that there was more abstract vocabulary in the keywords of the Q&A section, but the keywords in the review section, the words are the highlight with a high general meaning, which can psychologically satisfy consumers' need to know the details of the products. Therefore, although the topic consistency did show significant results in the above-mentioned study, if we future deepen the results and focus on more fine-grained levels (e.g., thought, meaning), we may be able to explore more new directions.



Figure 3: word cloud graphs of review section and Q&A section.

## DISCUSSION AND CONCLUSIONS

To sum up, the OLS results prove that the difference did exist in the component area perspective. First, same as prior literature (Nguyen & Chaudhuri, 2018), the content richness has a positive effect on the outcome of the sales; besides, the Q&A section (vs. review section) indicates greater sales. Second, there is an interesting result as the topic consistency was proved to have a negative influence on the proxy of sales. Third, results show the number of reviews and answers cannot affect sales, and this could result from customers' caution of decision making (Tellis, 2019).

The study made contributions in academic and managerial aspects. First, it made comprehension of prior research on WOM richness (Nguyen & Chaudhuri, 2019) and review quantity (Marchand *et al.*, 2017; Colicev *et al.*, 2017) in affecting the sales. Second, both the ELM model (Petty & Cacioppo, 1986) and information overloading theory (Luo *et al.*, 2013) are developed in this paper. Further, we prove the relationship between information selection and information source characteristics in the process of consumer decision-making, which provides a new perspective for WOM research. In managerial implication, previous studies about WOM in the micro-level mainly focused on the field of psychology and laboratory environment. We made up for the perspective of the actual purchase situation in the practical test (Packard & Berger, 2020; Bastos & Moore, 2021).

In addition, our study also has limitations. As a whole, this study uses a relatively small sample of appliance data collected from JD mall, and this might limit its external validity. Therefore, the findings should be generalized with caution. In a further study, we may utilize a higher quality sample containing more products and from a multi-platform. Based on the rich corpus of WOM, more micro-level research is expected to be taken. We believe that the breadth of WOM can be broadened in this case.

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## Knowledge-Based Clubhouse Adoption Intention in the Post-COVID-19 Era in the Hospitality Industry

(Work in Progress)

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### ABSTRACT

The COVID-19 pandemic has affected the digital transformation of the hospitality industry and triggered Clubhouse knowledge adoption behavior. Clubhouse engagement in the COVID-19 era has gradually changed the forms of communication. Hospitality industry owners can communicate about their interactions and trades through Clubhouse, and members can share their operating and management experiences. Therefore, hospitality industry owners can learn from and support each other. This study aims to bridge the gap between professional knowledge and management adoption in the community of hospitality industry owners. We treat members' self-regulated and socially regulated learning styles as variables in our analysis of members' behaviors after acquiring knowledge from the community. This study contributes to our understanding of knowledge-based digital transformation processes in the hospitality industry in the post-COVID-19 era. It has implications for both Clubhouse users and hosts.

*Keywords:* Hospitality Industry, Clubhouse, Post-Adoption Behaviors, Regulated Learning Framework, Benefit-Risk Framework

### INTRODUCTION

The popularity of the Internet has led to the rise of social media, the platforms of which have evolved with advances in communications and devices. Social media models that enable knowledge management include traditional messaging platforms and social communities based on voice, such as Clubhouse. The expansion of knowledge communities online in the hospitality industry has increased the number of restaurant owners starting businesses through Clubhouse. The characteristics of Clubhouse provide increased merchandising opportunities for members and partnerships among stores. As a result, Clubhouse communities can act as small entrepreneurial accelerators.

Restaurant owners can establish Clubhouse environments through social interactions to exchange product knowledge without the restriction of geographical boundaries or differences in time zones, cultures, languages, or other factors (Boyle & Johnson, 2010). To develop an outsourcing community for entrepreneurs, communities can use the hospitality industry model to search for supply chains and business knowledge. In this study, we investigated a virtual entrepreneurial hospitality community that shared professional information and explored whether and why its users were satisfied with the business information obtained through it.

Hospitality models are changing rapidly because of advances in knowledge and technology. The food and beverage model of entrepreneurship can be easily replicated, as it has a short technology cycle. Clubhouse members can identify the skills, abilities, and self-regulated and socially regulated learning of their peers. This learning relationship is established within professional hospitality communities. Each community provides members with the opportunity to share their needs and skills with others. As a result, through consultation or professional resources, Clubhouse members can meet the technical and capacity needs of the industry.

During the ongoing COVID-19 pandemic, the hospitality industry has experienced a dramatic increase in knowledge adoption through Clubhouse. This study investigated how Clubhouse members learn about socially regulated frameworks and how society influences their satisfaction with hospitality knowledge and behaviors (Iivari, Sharma, & Ventä-Olkkonen, 2020). Using the technology framework and the innovation climate to analyze the risks and benefits of mass engagement, we explored the satisfaction rate and the number of engagement behaviors that Clubhouse members adopt after mass engagement. In the food and beverage industry, members use professional knowledge to obtain support and mutual knowledge to create professional consultation networks (Lee et al., 2020). Clubhouse members consult with others in the community to assess the risks and benefits of the information received. Some members also share with others their professional knowledge and skills. Therefore, they use the innovation climate to interact with other community members.

The mutual benefits shared among Clubhouse members are built on the technology framework, and compared with other industries, the hospitality industry relies less on skills and knowledge consultancy (Iivari et al., 2020; Lee et al., 2020). Other community members enhance their knowledge or skills through consultation proposals, thereby learning self-regulation and self-improvement. If self-learning does not meet a member's needs, he/she can consult with others to obtain the required knowledge or information.

Community members can acquire the latest industry knowledge and skills by sharing their needs in the social environment. This process helps the knowledge community of hospitality professionals to develop a consultation process. By improving the accuracy of consultations, knowledge, and solutions, Clubhouse members have higher levels of satisfaction. The ability of Clubhouse members to assess the risks and benefits of using their professional communities and the ability of these communities to exchange innovative information develop as the members engage in socially regulated learning. Members feel that they receive effective output from their hospitality community and seek to ensure industry satisfaction.

Clubhouse members can obtain skills or professional information in virtual professional communities by outsourcing. For community members who require entrepreneurial expertise, the knowledge of influencing others can be a business model accelerator. In this study, we have the following two key objectives:

- (1) To explore how the adoption of regulated learning (self-regulated and socially regulated) in a community of hospitality experts affects their behavior (e.g., Clubhouse members' satisfaction and participation).
- (2) To understand how the outsourcing of knowledge of benefits and risk frameworks (benefits and risks) in the hospitality industry influences community members' normative behavior (self-regulated and socially regulated learning).

## **LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT**

### **Post-COVID-19 Pandemic in the Hospitality Industry**

Studies (Huang et al., 2020) that investigate the impact of crisis (diseases) on hospitality and tourism have received great academic attention. Especially, emphasis is placed on the economic impacts, labor-related issues, and learning (Huang et al., 2020). It is important to underscore that apart from the COVID-19 pandemic, similar infectious diseases have been experienced. Notable among these are severe acute respiratory syndrome (SARS), H1N1 influenza, Ebola, and the Middle East Respiratory Syndrome.

The COVID-19 pandemic has had serious consequences for the hospitality and tourism industries. In their studies on the impact of COVID-19 on the hospitality industry, Huang et al. (2020) found that business closures attributed to the COVID-19 pandemic caused significant declines in employment and affected the operations of small businesses in the industry. Moreover, COVID-19 has enhanced risk and health awareness in the hospitality industry (Davahli et al., 2020; Iivari et al., 2020).

Therefore, employees in the industry are motivated to comply with COVID-19 protocols, which transformed their perceptions and safety procedures during the pandemic. Iivari et al. (2020) argued that the best way to revive and sustain the hospitality industry during the COVID-19 era was to practice multiskilling and professional development hygiene practices and better crisis preparedness, among others. COVID-19 has influenced the digital transformation of the hospitality industry and triggered Clubhouse knowledge adoption behavior. In their study of virtual community engagement in the COVID-19 era, Lee et al. (2020) found that cyber entrepreneurship was prevalent, with businesses embracing community engagement to survive.

The advent of the COVID-19 pandemic has triggered the need for hospitality entrepreneurs to rely heavily on technological advances. Therefore, cyber entrepreneurship enables business owners to obtain relevant marketing information, understand consumer perceptions, and develop innovative products through voice communities. This has resuscitated the use of artificial intelligence and social service robots' technologies during the pandemic as public safety issues have become critical. It is not surprising that technology has become indispensable condition-sine-qua-non during and post-COVID-19 (Gretzel et al., 2020). The COVID-19 has conscientized the need for innovative technologies and business models (for example, virtual offices) to ensure sustainable development (George, Lakhani & Puranam, 2020). Nonetheless, these studies (Gretzel et al., 2020; Gursoy & Chi, 2020) provided the need for technology to sustain and make the tourism and hospitality industry resilient during the COVID-19 pandemic. They did not address the extent to which regulatory learning in Clubhouse is affecting behavioral adoption during the COVID-19 pandemic.

### **Professional Knowledge Outcome Satisfaction**

Chen, Chang, and Liu (2012) argued that the availability of knowledge and technology solutions could help hospitality community members to improve their consulting strategies and adjust their business models to enhance their technical capabilities and market responsiveness. Knowledge and information are shared to enable entrepreneurs to make decisions within their budgets based on consultations. Clubhouse members' satisfaction with the knowledge and technology provided in their community is reflected in their post-adoption behavior (Chou, 2020). The content of messages during consultations and the consultation output status after adoption affect Clubhouse members' satisfaction with knowledge in a community (Chou & Hsu, 2018; Chou & Hung, 2016). However, the hospitality expert community has many types of relevant consultation and outsourcing information. Clubhouse members can pursue knowledge and skills that suit them and industry trends. If members cannot produce new things, they can develop them in the community, similar to building new products.

As an online community transforms and grows, the number of its members seeking support and expertise increases, and competition in fast-moving markets intensifies. With limited resources, how can businesses obtain the right support through this type of community? A professional community can provide timely and useful solutions or outsource trade between members. By communicating their needs, members' concerns can be quickly addressed and useful suggestions shared. These factors affect the satisfaction of members of the hospitality industry with the community (Chou, 2020; Zhao, Lu et al., 2012).

The clubhouse is a member invitation-only voice virtual community. Member satisfaction positively affects users' adoption behaviors based on similar interests and whether activities are focused on learning or sharing (Chou, 2020; Ma & Agarwal, 2007). As indicated by their level of satisfaction, the perception of an event is important in evaluating the decision of community members to unadopted or adopt knowledge and technology. Member satisfaction with community interactions on technology and knowledge is an essential reference point in making consultation decisions (Chiou, 2004). Clubhouse members' increased satisfaction with the knowledge and technical content shared in a community leads to proactive post-adoption behaviors, including responses and interactions. Based on the above discussion, we propose the following hypotheses.

Hypothesis 1: Hospitality Clubhouse members' self-regulated learning positively affects the community's satisfaction following the adoption of shared knowledge.

Hypothesis 2: Hospitality Clubhouse members' socially regulated learning positively affects the community's satisfaction following the adoption of shared knowledge.

### **Self-regulated Learning**

"Self-regulated learning" refers to a social cognitive theory process through which people understand their deficiencies by acquiring, enhancing, or correcting their technical and professional skills (Pinder, 2014). In a hospitality industry community, the exchange of information among members raises individuals' awareness of the knowledge and skills they lack. Members self-evaluate the effectiveness of their knowledge acquisition and skill development through self-regulated learning. They learn independently or seek support from outside groups and delegate skills from the process to their thought practice through consultative learning (Wan, Compeau, & Haggerty, 2012). CLUBHOUSE members who have a high degree of self-regulated learning can study independently or off-site, depending on their objectives. Highly self-regulated CLUBHOUSE members actively respond to new information in the hospitality industry community and initiate discussions to assimilate their knowledge. When they encounter obstacles, they are proactive in finding solutions. They also establish a procedure for self-assessment of the need for consultative learning, thereby determining whether consultation is needed on essential items and judging the output benefits (Wan et al., 2012).

In a hospitality industry community, when a member releases new technology and knowledge, self-regulated learners absorb and discuss the information. "Self-regulated learning" refers to the active, goal-directed self-control of an individual's motivation, cognition, and behavior to achieve a goal (Pintrich, 1995). Hospitality CLUBHOUSE members with a high degree of self-regulated learning plan their learning objectives according to the knowledge community's attributes.

These types of members take the initiative in understanding the founding owners of hospitality businesses. They consult them to absorb their information. When faced with similar knowledge and technical consultation needs, they consult others in the professional community. The practical operationalization and validation of the results and the internalization of their knowledge and skills factor into future consultative projects. We proposed the following hypotheses.

Hypothesis 3: The benefits framework of hospitality Clubhouse members positively affects group members' self-regulated learning.

Hypothesis 5: The risk framework of hospitality Clubhouse members positively affects group members' self-regulated learning.

### **Socially Regulated Learning**

The most significant differences between virtual and physical communities lie in the interactions between members and in the influences within the communities. Hospitality Clubhouse members' self-regulated learning helps individuals to solve problems and overcome obstacles through discussion. The fixed topics and professionalism of a community allow Clubhouse members to be influenced by the community's social regulations as they work together on entrepreneurial issues in the hospitality industry. Co-learning involves active participation in cognitive restructuring (Lim & Beatty, 2011). The interactions between community members enhance the exploration of expertise. In addition, the professional atmosphere of the hospitality community regulates the professional skills and knowledge required by Clubhouse members through social groups (Hsu, Chou, & Min, 2015).

In brick-and-mortar establishments, knowledge or skills transfer training takes place within an organization. Usually, the members of an organization come from different departments and do not know each other. "Socially regulated learning" refers to individuals learning from each other in groups to accelerate the acquisition of skills and knowledge during training (Wan et al., 2012). Compared with physical organizations, voice communities are less likely to trigger socially regulated learning. Thus,

they need to develop their professionalism and their specificity. The hospitality community that we selected for this study was purposeful in its skills and knowledge learning.

People join such a community to gain work-related knowledge and skills or consult others to improve performance. Socially regulated learners require relatively little time to acquire skills and knowledge through exchanges with Clubhouse members. Interactive learning reduces alienation. When socially regulated learners encounter a problem that they cannot solve, they delegate it to other members or discuss it with them. This arrangement reduces the cost, risk, and uncertainty associated with starting a business. Hospitality professionals with higher levels of socially regulated learning behaviors absorb new knowledge and skills from other Clubhouse members. Through the exchange of knowledge and skills, Clubhouse members can learn on their own or delegate the acquisition of relevant skills and knowledge to other members. Applying socially regulated learning to professional communities in the hospitality industry, Clubhouse members can learn about trends in the industry that may make entrepreneurs vulnerable to problems. Other members can either propose relevant solutions or consult on the issue. Clubhouse members can also grow with advances in knowledge or technology, and socially regulated learning accelerates the acquisition of this information. We proposed the following hypotheses.

Hypothesis 4: The benefits framework of hospitality Clubhouse members positively affects group members' social-regulated learning.

Hypothesis 6: The risk framework of hospitality Clubhouse members positively affects group members' social-regulated learning.

### **Benefits Framework**

The benefits framework represents the potential risk for entrepreneurs to use the hospitality knowledge community and expand the use of the hospitality industry. Unlike a traditional supply list, this knowledge-adopted framework involves several innovative attempts. The potential advantage of maintaining technological innovation through professional communities is that it increases motivation for mutually beneficial collaboration among professional community members (Gatignon & Xuereb, 1997; Mishra & Agarwal, 2010). The uncertainty of adopting innovative concepts in the community is reduced by ensuring that hospitality Clubhouse members have more information, technology, or knowledge when they search for resources (Rogers, 2010). The more information Clubhouse members have about their expertise and skills, the more likely they are to integrate resources. Understanding the feasibility of knowledge and technology and effectively consulting or contracting solutions demonstrates the professional community's strengths (Premkumar, Ramamurthy, & Nilakanta, 1994). Limited resources and technical conditions usually restrict entrepreneurship in the market. Through its professional community, the hospitality industry can generate solutions at a lower cost. More collaborative benefits support innovative solutions that facilitate entrepreneurship in the market through technical support and services (Mishra & Agarwal, 2010).

### **Risk Framework**

The risk framework offers an innovative way for the hospitality community to consult on knowledge and technology. However, it may collapse because of the uncertainty of a business model in the virtual cluster of the hospitality industry. In this study, "risk framework" refers to the professional discussion communities joined by founding owners. The risk framework also tends to lead to the replication of knowledge and technology with a common purpose, and the resulting loss of opportunities can negatively affect the business model (Mishra & Agarwal, 2010). The risk framework and potential losses in the hospitality community may be directly related to the knowledge and technology discussed in a consultation. The risk framework may reduce the benefits generated by the original benefits framework or may result in more severe losses, leading to technical or process failure in the hospitality industry. Avoiding the possibility of losses when using consultative innovation strategies may require the assessment of acceptable risk (Jackson & Dutton, 1988). Traditional supply chain outsourcing research also has a risk perspective and argues that risk arising from limited resources could innovate the development of business models.

Members of the hospitality industry community may have different goals and needs, which can result in different objectives for the community. Some Clubhouse members are required to make consultation demands, while others are contracted. Under information imbalance and limited resources and capital, the strategy is to seek out community members to consult and share technology and process components. Collaborative models in Clubhouse's are less likely to create traction. The risk of failure can only be reduced through the power of the group. The control and coordination of content in the hospitality industry can reduce the risk that may arise when there is cooperation.

### **Control Variables**

In this study, control variables were included in our research model to ensure that individual factors not directly related to the study did not affect the dependent variables. Knowledge adoption outputs (professional knowledge output satisfaction, community member engagement behavior) may differ depending on the industry context. Therefore, this study prioritized the hospitality industry as a control variable (Venkatesh et al., 2003).

## **RESEARCH METHOD**

### **Research Method and Design**

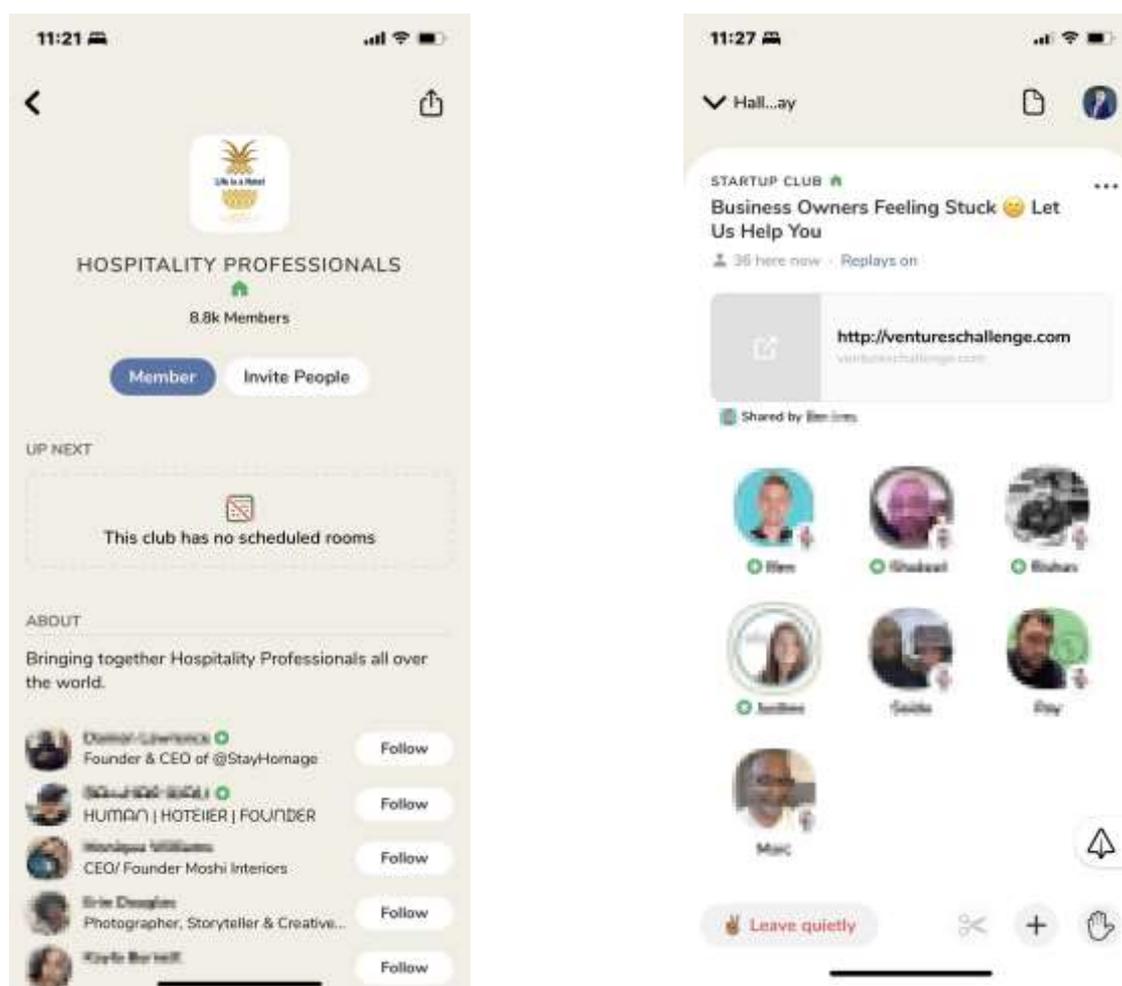
This study used the benefits and risk frameworks from cognitive theory to analyze how members of the hospitality industry community socially regulate and self-regulate their learning using benefits and risk frameworks in a climate of innovation. The growing satisfaction of hospitality industry members with the skills and knowledge of the community is indicated by self-

regulated and socially regulated learning. We treated Clubhouse members' use of post-enterprise professional community knowledge and skills in building behaviors in the hospitality industry as a measure. We sought to understand whether learning through social or self-regulation changes the adoption behavior of a professional community. Uncertainty over peers' knowledge and skills in delegating issues may lead to failure in the hospitality industry, based on low satisfaction and post-adoption behavior. Figure 2 shows our research framework, based on the literature review and hypothesis development. Data was collected from Clubhouse. The study obtained data from the purposive sampling technique. In other words, respondents were selected based on our judgment and their suitability to address the research questions posed. The questionnaires were administered online to Clubhouse members to elicit information on their regulatory learning and how it affects their behavior, and how innovation and technology frameworks influence the normative behavior of community members.

### Structural Model Analysis

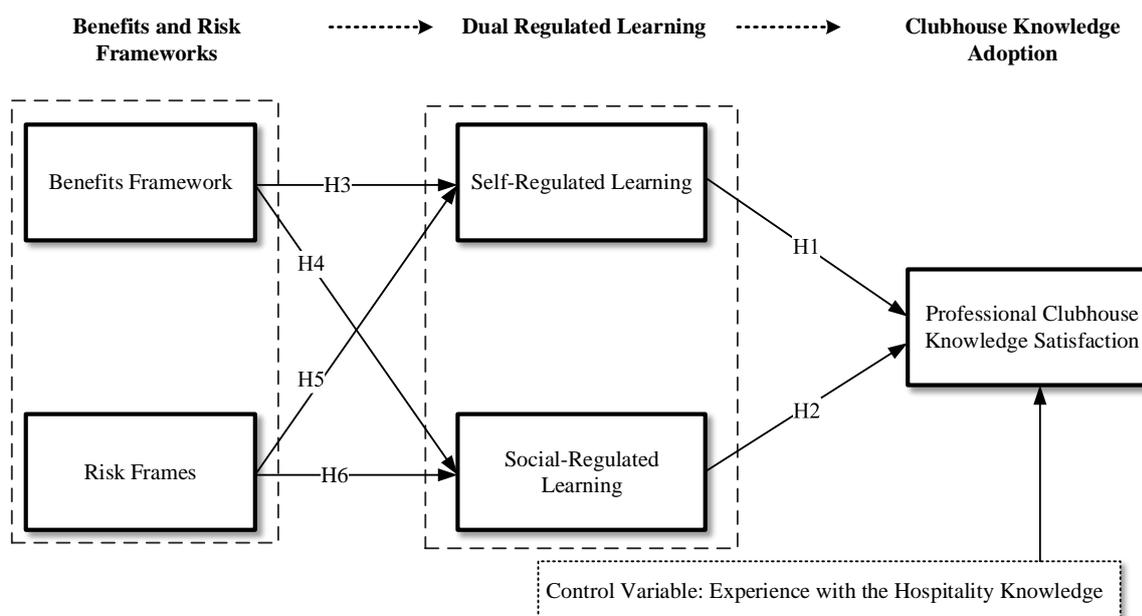
Structural equation modeling was used to explain the causal relationships between potential variables. The theoretical model was built by checking the relationships between the independent variables of the model and the settings between the variables. Causal analysis and model construction between the variables were used to determine the validity of the model (Hair et al., 2018). The purpose of the structural model analysis was to identify and verify the causal relationships between the variables. We examined the effect of different knowledge adoption outputs (e.g., expertise satisfaction and post-adoption behaviors) and the innovative technology framework (e.g., benefits framework, risk framework, and innovation climate) on dually regulated learning (i.e., Clubhouse members' self-regulated and socially regulated learning).

We will verify the findings with SmartPLS statistical software. The main measurements were the  $\beta$  value and the R<sup>2</sup> value. The  $\beta$  value is a measure of the correlation between the independent and dependent variables, and the R<sup>2</sup> value is the explained power of the variables. The results of the structural model analysis were used to verify the causal relationships between the variables. We conducted the main effects analysis of the structural model using the relevant variables as the benchmark.



Source: This study.

Figure 1: Clubhouse interface



Source: This study.

Figure 2: Modified Research Model

## RESULTS

### Expected Contribution in this Research

There is value in transforming the exchange of knowledge and technology through interactions between professional community members. Such members can gain business benefits through consultation and enhance their satisfaction and adoption through behavioral research. Knowledge and technology adoption models from professional communities can reduce consultation uncertainty and guide the exchange of knowledge and technology within professional communities. Clubhouse members use their professions to consult or achieve mutually beneficial business model growth. However, Clubhouse members' decisions on whether to adopt knowledge are based on their ability to assess the related risks and benefits. Therefore, in the dual-regulated learning model, there is a preference for individual self-determination. The benefits and convenience of Clubhouse expertise are recognized as beneficial to the hospitality industry. The highly evaluated self-understanding of risks and benefits of community members affects their self-regulated learning behaviors. In the research model, the innovation climate is like a group of socially influential individuals in the hospitality knowledge community. The atmosphere is generated by the abilities and orientation of community members. The innovation climate is likely to have a positive effect on socially regulated learning. Try to find the result to be consistent with the social exchange theory of the benefit/constraint binary framework of the self and the community.

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## Research on Image Perception of Luxury Hotels in Dalian Based on Text Analysis

(Work in Progress)

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### ABSTRACT

In recent years, with the development of mobile Internet and smartphones, more and more consumers will share their feelings and thoughts after staying in the hotel on the website, thus forming many online comments. These online comments reflect consumers' perception of the hotel image to a certain extent. This paper uses Python to collect 35977 online comment data of luxury hotels in Dalian. Through the analysis of high-frequency words, characteristic words, and comment emotion, it is found that the main factors affecting the perception of hotel image are: hotel location, room condition, environmental sanitation, service attitude, and professional ability of receptionist and other service personnel. Finally, according to the research conclusions, provide personalized suggestions for the hotel to improve its image.

Keywords: text analysis; luxurious hotel; perception of image

### INTRODUCTION

In recent years, the Internet has become the fastest-growing industry. According to the statistics of the 47th "Statistical Report on Internet Development in China" issued by CNNIC (China Internet Network Information Center) (2021), as of December 2020, the number of Internet users in my country is 989 million, compared with March 2020. There were 85.4 million new netizens per month, and the Internet penetration rate reached 70.4%, an increase of 5.9 percentage points from March 2020. At present, the consumption patterns of consumers booking hotels online through smartphones are becoming more and more extensive. For the unique product of hotels, it is difficult for consumers to fully understand the actual environment, services. With specific conditions such as catering and transportation, more and more consumers have become accustomed to searching for online comments previously posted by consumers on third-party platforms or on the hotel's official website as a reference before booking a hotel. These online comments express the true thoughts of consumers who have already experienced the hotel, and at the same time, convey the consumer's perception of the hotel's image. According to the China Online Market Research Report in 2019, 80.1% of consumers purchase goods online; online word-of-mouth will significantly impact them. Hotel online comments provide a convenient, reliable, and comprehensive reference for consumers to buy and provide a channel for hotels to discover their advantages and disadvantages. Through in-depth research on online comments and discussing consumers' perceptions of the hotel's image, suggestions can be made for hotels to improve their image. However, in the face of massive online comment data, how to find the information of interest is a significant research problem. Therefore, this article will focus on this issue.

### LITERATURE REVIEW

Hotel image refers to consumers' impressions and evaluation of the hotel's business process. If a hotel wants to stand out from the fierce competition, it must show its differences. The most effective way is to establish a good hotel image. Shuai and Zou (2019) pointed out that online comments will affect consumers' buying behavior to a certain extent. Have a particular impact on the image of the hotel. In foreign research on hotel image perception, Adnan *et al.* (2021). proposed that hotel service scenarios involving the substantive and communication stages will impact customers' image perception. Chen *et al.* (2014). proposed that the hotel's physical equipment, such as decoration and environment, as well as the hotel's response to customer perception, will have an impact on the hotel's functional image perception. Durna *et al.* (2015). found that service landscape components have a positive impact on the overall image, and the overall image has the same impact on consumer reputation and revisit. Xie *et al.* (2016). pointed out that front-line employees will have a greater impact on the establishment of hotel image, and the establishment of luxury hotel image mainly benefits from managers. In the domestic research on image perception, there are little researches on hotel image perception, and there is almost no research on luxury hotel image perception. In recent years, domestic research on image perception has focused on the level of tourist destinations. Sultan *et al.* (2021) proposed that tourists' perception of scenic spots is mainly based on positive emotions. The mental image can be summarized as tourist environment, attractions, facilities and services, and tourism—management and travel experience. Durna *et al.* (2019) put forward and analyzed the reasons for guest complaints and proposed countermeasures to resolve complaints against guest complaints, which is conducive to better building the hotel image.

Most of the research on hotel images obtains relevant data through questionnaires and then uses AMOS software and SPSS software to analyze the data. Compared with many online comments, the use of questionnaire surveys to explore the factors that affect the perception of hotel image is limited by time, space, and cost. If you do not use effective methods or tools for analysis,

it will inevitably lead to many online comment resources being wasted. In recent years, many scholars have started research based on text analysis. There are many data sources for text analysis, and the most popular one is to use python programming to crawl data. Sun and Guo (2020) used python to crawl the comments posted by tourists on the Internet. They analyzed the frequency of commonly used words, word cloud and co-occurrence network, and other image characteristics. Based on python crawling data, Guo *et al.* (2017) further used data mining methods and potential Dirichlet analysis (LDA) to determine the critical dimensions of customer service expressed by hotel visitors. And most of the research on online hotel comments is mainly conducted on the TripAdvisor website, and there is little research on online comments on "Ctrip." In summary, using different research ideas and methods to dig out the valuable information in online hotel comments is necessary to understand consumers' true inner thoughts and convey consumers' perceptions of the hotel's image.

#### DATA COLLECTION AND DATA PROCESSING

This article uses automation technology for data collection and analysis to explore consumers' perceptions of hotel image through online comments. This article uses python crawler as a collection tool to collect online comments of five-star/luxury hotels in Dalian on Ctrip. The collection time is from April 7, 2021, to April 8, 2021. First of all, search for hotels on "Ctrip", input destination "Dalian", select "five-star/luxury" for hotel level, check-in time is not selected, the default check-in time is the date of the hotel query day, check-out time is the next day, a total of 26 hotels found. After statistics, it is found that the number of comments of different hotels varies greatly. The Shangri-La Hotel, Dalian, with the most comments, has 5432 online comments, and the Dalian Liangyun Chuanqi Hot Spring Hotel, with the least number of studies, has only 22 online comments. For the convenience of subsequent research, this article selectively crawled online comments of hotels with more than 1,000 online comments. Finally, a total of 45,843 online comments of 17 five-star/luxury hotels in Dalian were collected and saved in an excel file. This article chooses "Ctrip" as the data source for the main reasons: First, "Ctrip" is the current online hotel booking industry giant, and the users are relatively large; second, the comments are also rich in content and updated quickly, which is more researchable.

After quick browsing of the collected online comments, it is found that the emotions of the comments are both positive and negative. The content of the studies also covers all aspects of the hotel, such as service attitude, location, traffic environment, hygiene, food, parking, etc. Some comments collected are shown in Table 1.

Table 1: "Ctrip.com" hotel online review form.

hotel name	commentator	score	comments
Shangri-La Hotel Dalian	kimchenkim	5	Shangri-La has never let me down. The room is clean, and there is no smell of smoke. I take the initiative to clean two or three times a day and take the initiative to replenish drinking water.
Kempinski Hotel Dalian	3001878****	4.8	The breakfast is rich, combining Chinese and Western, and the porridge is delicious. The room has the luxury of an old-fashioned hotel. Although it is a stilted room with a relatively long corridor, it is designed with great consideration.
Grand Hyatt Dalian	M417732	3.0	It may have been a long time because there was not much business. Suddenly a large number of guests came to this Qingming holiday. The front desk and breakfast were not prepared, and the attitude was good, but he was busy, and the breakfast was average, which was only worth fifty.

This article adopts the text analysis method. The text analysis method is to go from the surface of the text to the deep level of the reader to discover the deep meanings that ordinary reading cannot grasp. Through computer network technology, the original content is transformed into a quantitative description that the machine can recognize to identify and judge the focus of user-generated content in a certain period. When conducting text analysis, the researcher must exclude personal subjective colors, proceed from the existing materials, complete an objective, comprehensive, quantitative, and systematic study of the materials, and use mathematical-statistical methods to conduct quantitative analysis of the materials studied.

This article uses text analysis to study the online comments of five-star/luxury hotels in Dalian with more than 1,000 comments. Among them, there are many invalid comments in all the crawled online comment text data. Invalid comments mainly include four categories. The first category is multiple comments by different users with similar content and various frequent comments on the same hotel. This type of review is likely to be deliberate by hotel merchants to increase sales and improve the average hotel rating. Invite others to copy and paste comments of ready-made positive comments. This type of review is generally longer, covers all aspects of the hotel, and the repetition rate of comments is relatively high. The second category is a piece of word-count comments published by consumers to complete some tasks on the platform or hotel. Some of these comments have nothing to do with the check-in experience. It is to make up the word count. The third type of comments are not considered consumer

comments in the strict sense, but system comments. For example, if a user just scores and does not write a comment, the system will automatically generate "the user has praised" and "the user has already commented" in the comment column after a few days. Such comments are of no research value. The fourth category is commented in languages other than Chinese because the rest of this article is a study of Chinese. The analysis tools used are also based on Chinese, so even if the content of an English comment meets the requirements, it will not be used.

**DATA ANALYSIS**

In this paper, combined with network technology and manual analysis, firstly, the collected online comments were deleted duplicates and simple manual screening in Excel, eliminating 9866 invalid comments and finally obtaining 35977 valid comment data. After a simple screening of the collected online comments, this article uses python to perform participle, word frequency statistics, characteristic words, and emotion analysis to explore the focus of consumers on various aspects of the hotel and find valuable information in it so as to research through online comments Consumers' perception of the hotel's image.

**Participle**

The participle is the process of recombining consecutive letter sequences into word sequences according to certain specifications. For example, one of the online comment of a hotel is, "The transportation is convenient, the bus station and the subway station are at the door; the business district is around the hotel; the rooms are large, the facilities are complete", the results afterword participle are: "The", "transportation", "is" "convenient", "the"," bus station ", " and ", "the", " subway station", "are", " at the door ", "the", " business district ", "is". "around", "the". "hotel", "the", "room", "are", "large", "the", "facilities", "are", "complete".

**Word Frequency Statistics**

Word frequency statistics is a method of lexical analysis and research, through the study of the frequency of words, so as to find the meaning in it. After numbers, words, URLs, pronouns, and adverbs are eliminated, and finally, a total of 17,498 words are obtained. Many of the words e are meaningless for the research. Some invalid words have been removed through manual screening, such as "Dalian" and "Five-star" because this article is about the online comments of five-star/luxury hotels in Dalian. Therefore, the frequency of "Dalian" and "Five Stars" appearing in the comments is quite high, but there is not much reference significance for the research of this article. Another example is: "this," "you," "what," and other words used to assist language expression. These words are also words with high frequency, but there is not much research significance. Due to the too many results of word segmentation data, this article Only the top 40 words with word frequency as shown in Table 2 below are listed.

Table 2: Word frequency statistics table.

word	hotel	service	good	room	breakfast	location	Reception	convenient
Frequency	20092	11332	10446	9995	7091	6276	6125	4670
word	Yes	environment	no	facilities	check-in	clean	special	children
Frequency	4422	4039	3704	3702	3532	3408	3151	2613
word	feeling	satisfied	next time	attitude	enthusiastic	ordinary	sanitary	comfortable
Frequency	2301	2192	2089	2062	1916	1883	1863	1762
word	like	choose	experience	upgrade	geography	suitable	cozy	free
Frequency	1681	1680	1595	1556	1536	1479	1394	1388
word	traffic	square	sea view	recommended	abundant	staff	pieces	a lot of
Frequency	1360	1305	1293	1248	1229	1213	1200	1194

**Characteristic Words**

Extract useful words that appear more than 200 times from the participle results, identify these words manually, find out the nouns related to the hotel, and classify these words, so as to obtain the hotel’s characteristic words and their corresponding words. The characteristic words are shown in Table 3.

Table 3: Characteristic vocabulary and demonstrative vocabulary.

characteristic words	hardware	equipment	service	location	food
demonstrative words	room park lobby restaurant bathroom pool spa suite gym apartment area	facility air conditioner elevator toilet telephone tub slippers window television	reception manner praise great concierge soundproof professional quality atmosphere detail quality	traffic square seascape surrounding view market center floor distance garden fountain	breakfast smell fruit buffet dinner coffee

	hall		music characteristic excellent	subway sea beaches	
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**Semantic Network Analysis**

In order to deeply study consumers' perception of the hotel's image, this article also adds an in-depth analysis of the semantic relational network. The semantic relationship network is mainly embodied through social network diagrams. In the field of text analysis, social network diagrams are often used to describe and measure the relationship between words and words, reflecting the connection of words in a specific context. Because there are many words involved, this article intercepts the social network relationship graph with "next time" and "recommendation" as the nodes and focuses on the discussion. Through the social network relationship graph, the deep meaning of the comments text can be explored so as to understand the consumer's perception of the hotel's image.

**Emotion Analysis**

This article uses Python for emotion analysis. An example of an emotion dictionary is shown in Table 4. Among them, emotional words with a positive value express a positive direction and vice versa. Different emotional words convey different degrees, and words with different degrees have different weights. After the comment content is split into sentences, emotion analysis is performed on the words in it, and the data perspective is drawn in excel, as shown in Figure 1. It can be seen from the figure that positive emotions account for the largest proportion, accounting for 56.1%, followed by neutral emotions, accounting for 35.8%, and finally negative emotions, accounting for 8.2%, which is 47.9% lower than positive emotions. This shows that the vast majority of consumers' emotional tendency is positive.

Table 4: Examples of emotional dictionaries.

Type	Emotional Words	Weight
Positive words	fashion	1
Negative words	behind	-1
Degree word	extreme	2
Negative Words	possible	-1

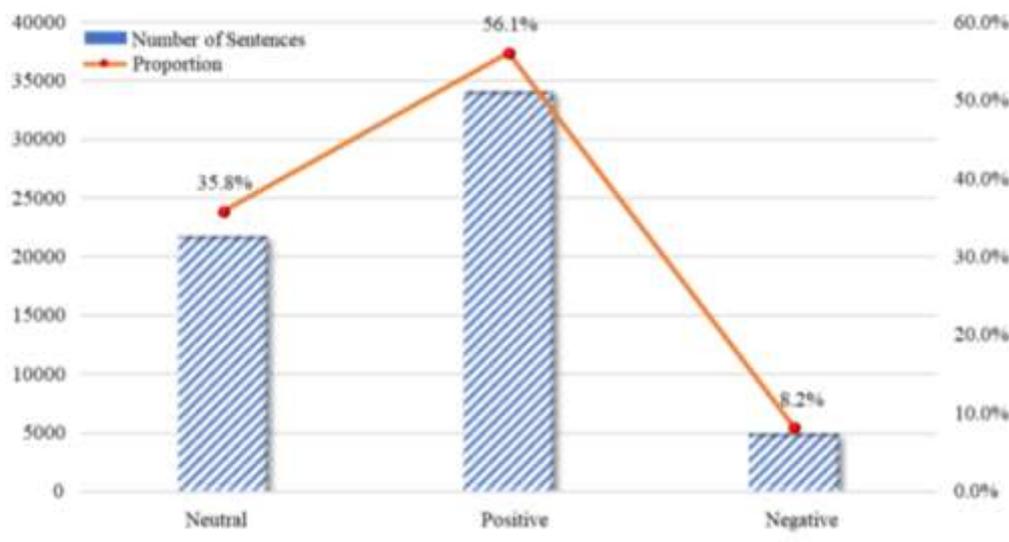


Figure 1: Distribution of sentiment tendency of sentences

According to the rules of the emotion dictionary, using the sentence as the most basic unit, analyze the positive words, negative words, degree words, and negative words that appear in the sentence to initially determine the emotion tendency of the sentence, and then match the split sentence with the original data. Count the number of positive sentences and negative sentences contained in each piece of the original comment data, and then calculate the positive score and negative score to get the total score. The higher the score, the greater the positive tendency of the reviewer, otherwise the opposite. For example, a reviewer says, "I always live here. I always feel very good, and the environment, the surroundings are good. The hotel is a bit old, and the facilities in the house are a bit outdated. I hope it can be updated, and it may improve a lot. The breakfast type is not too much, and too monotonous". According to the emotion dictionary, "good" gets 1 point, the degree word "very" has a weight of 3 points, and "monotonous" and "no" are both -1 points. In the end, the total score of the review is 1 point. Consumers, on the whole, have a positive emotional tendency towards hotels.

The emotion analysis score ranking positive 50 comments (highest score 198 points) and bottom 50 comments (lowest score - 63 points) were separately filtered and copied to the excel table, and the second-word segmentation was performed. Counting the results of a participle, the words with higher frequency in the high-score and low-score comments are shown in Table 5.

Table 5: High-frequency vocabulary list.

high score	low score
Service	Room
Room	Service
Reception	Reception
Health	Reception
next time	Clean
Warm	Indifferent

## RESULT AND DISCUSSION

### Image Perception Analysis Through High-frequency Words

In the word frequency statistics table in Table 2, nouns have the highest frequency, accounting for 50.3%, followed by adjectives, accounting for 38%. These nouns mainly include hotel services, rooms, breakfast, location, front desk, environment, facilities, etc. The room is the place where consumers have the closest contact with the hotel. Consumers will stay in the hotel room for a relatively long time if the environment and hygiene of the room do not meet the expectations of consumers, even if other aspects of the hotel do well. The hotel's satisfaction in the hearts of consumers will not be too high, which will have a negative effect on the image of the hotel in consumers' hearts. For consumers staying in hotels, the front desk is their first impression of the hotel. If the front desk staff provides consumers with warm and attentive service, some minor problems encountered later will not be particularly concerned. However, if the front desk service is indifferent, consumers will feel that they have not received the treatment they deserve and will observe other aspects of the hotel with a scrutiny eye, which will seriously affect the image of the hotel in the minds of consumers. Adjectives mainly describe the above aspects and express the true thoughts and feelings of consumers. For example, in the word frequency analysis, the word "good" frequently appears (10,446 times in total), which shows that most consumers are relatively satisfied with the hotel.

### Image Perception Analysis Through Characteristic Words and Demonstrative Words

In Table 3, the characteristic words and demonstrative words are summarized for words that appear more than 200 times. It can be seen that the focus of consumers' attention is mainly on the hardware, equipment, service, location, and other aspects of the hotel. Content is an important factor that affects consumers' perception of hotel image. In the perception of hotel hardware, the high-frequency indicators involved are room, parking lot, lobby, and other words, restored to the original content of the online review, it can be seen that for the room, consumers are mainly concerned about the size of the room, The scenery outside the window and the sanitary condition. For parking lots, consumers are mainly concerned about whether there is a parking lot, whether it is convenient to enter and exit the parking lot, and whether the security of the parking lot is reliable. For the lobby, consumers are mainly concerned about the area of the lobby and whether there is a comfortable seating area. In terms of equipment, consumers are mainly concerned about whether the equipment is repaired and maintained and whether it is safe to use. In terms of service, consumers are mainly concerned about the attitude of the waiters at the front desk, guest rooms, restaurants, etc., and restored to the original content of the online comments. It can be seen that the enthusiastic and professional service will bring more praise to the hotel. The location of a hotel is one of the main factors that affect consumers' perception of the hotel's image. It can be seen that convenient transportation and beautiful scenery can help improve the hotel's image in consumers' minds through location indicators.

### Image Perception Analysis Through a Semantic Relational Network

Through the semantic relationship network, it can be seen that the word "next time" is related to "come again", "satisfaction", "like", "enthusiasm", "clean", "environment", "location", "front desk", "service" and words such as "room" are closely related. The word "recommend" is similar to the social network graph of the word "next time." It can be confirmed that consumers' perception of the hotel's image is affected by many factors such as the hotel's location, room conditions, environmental sanitation, the attitude and professional capabilities of the front desk and other service personnel.

### Image Perception Analysis Through Emotion Analysis

The emotion of collected online comments has positive and negative. Through emotion analysis on the collected online comments, we can find that most of the consumers' comments are positive, and these consumers are relatively satisfied with the hotel. From Table 5, it can be seen that regardless of whether it is a comment with a higher emotion analysis score or a comment with a lower score, consumers' concerns are mostly concentrated on "room," "service," "front desk," "hygiene" and "attitude." From this five information, it can be seen that whether the room is clean, whether the front desk is enthusiastic, whether the service is professional, and whether the attitude of the service staff is good are the focus of consumers' attention, and these aspects will directly affect consumers' perception of the hotel's image. In the participle results of comments with higher emotion

analysis scores, the word "next time" appears more frequently, and in a sample of 50 reviews, 41 reviews mentioned the word "next time," indicating that after consumers experience the hotel in person, if their feelings are same as expected, they will have a positive impact on the image of the hotel.

## RESEARCH CONCLUSIONS AND PRACTICE IMPLICATIONS

### Conclusions

With the development of the Internet and smartphones, the phenomenon of online shopping and online hotel reservations can be seen everywhere, and online comments have gradually become the object of research in academia. This paper conducts research on the five-star/luxury hotel online comments with more than 1,000 online comments in Dalian, uses text analysis technology to deeply analyze consumers' perception of the hotel image. The research results show that in the results of emotion analysis, positive emotions account for a larger proportion, followed by neutral emotions and negative emotions. This shows that most consumers have a positive attitude towards the image perception of luxury hotels in Dalian. Hotel location, room conditions, environmental hygiene, front desk, and other service staff's service attitude and professional ability are the focus of consumers' attention, and they are also the main factors that affect consumers' perception of the hotel's image.

### Practice Implications

Based on the above analysis, this article puts forward the following practice implications.

First, improve the facilities and equipment of the hotel. Hotel facilities and equipment will directly affect the image of the hotel in the minds of consumers and sometimes threaten the personal safety of consumers. Hotels should regularly inspect and maintain frequently used facilities and equipment, such as air conditioners, elevators, toilets, telephones, and bathtubs commonly used by consumers. The hotel should ensure that all facilities and equipment meet the standards that a five-star hotel should have before consumers move in.

Second, strengthen the training of service personnel and improve their service awareness. Many consumers commented that the quality and professional abilities of service personnel are low, which is inconsistent with the hotel grade. Therefore, hotels should strengthen professional training for all service personnel, encourage employees to provide consumers with positive and enthusiastic services, pay attention to the details of the service process, and make consumers feel at home.

Third, hotel management should pay attention to consumer comments. In these comments, consumers will express their true experience of staying. Some comments praise the hotel for doing a good job in some aspects, some comments single out the bad aspects of the hotel, and some consumers also say about the hotel. The areas that need improvement and upgrades put forward their own suggestions. The true feelings from consumers are the entry point for the hotel to improve its services and improve its management level. However, many hotels respond to a single stereotyped content under the comments of different consumers, and most of the replies are not appropriate to the consumer's comments, so consumers will also feel that their comments have not been taken seriously.

Fourth, find the correct positioning and improve the level of competition. In the word frequency statistics, the frequency of the word "not worth" is also higher. Clicking on the detailed content of the word and simply reading the comments related to the word "not worth," you can find many things that make consumers feel worthless—the main aspect of the hotel, but the details such as mineral water and toiletries. Many consumers complain about the use of the cheapest mineral water on the market and the toiletries of unknown brands, which makes them suspect that they are not living in a five-star hotel, and their overall satisfaction with the hotel is at a low level.

### Research limitations and Prospects

This article inevitably has some shortcomings. According to the shortcomings of this article, future research can expand the scope and samples of the research. For example, it can conduct research between the same star-rated hotels in different cities or conduct research between different star-rated hotels in the same city to study consumers' perceptions of the hotel from multiple perspectives. Research in this area can also strengthen empirical analysis, combining online comments and questionnaires to conduct research. Future research can conduct preliminary analysis through online comments and then select variables with obvious effects to design the questionnaire so as to design the questionnaire in an all-around way—research on the perception of hotel image.

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## Research on the Effects of Youth Personalities on Impulse Purchasing Intention

(Work in Progress)

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### ABSTRACT

Youth are the main group of social media users, but there is limited literature on the influencing factors of impulse consumption tendency that focus on youth. This research mainly studies the influence of teenagers' personality traits on impulse buying. We attempt to the mediating effect of upward social comparison and the moderating effect of emotion. We design a questionnaire with measures of personality, upward social and emotion in the recent one month. We expect that the positive/negative emotion would moderate the direct influence of personality traits on impulse consumption and the indirect effect of upward social comparison on impulse consumption. The study not only contributes to the youth purchase behaviors but also links the connections among the personalities, emotions, and purchase intention.

*Keywords:* Big-five model; impulse purchasing intention; upward social comparison

### INTRODUCTION

#### Social Network and Personality

Instant messaging, search engines, online news, online payment, online shopping, online banking, and other kinds of mobile Internet applications have deeply embedded all aspects of people's life and work life, which builds a new social form and a basic way of life. According to statistics from the International Telecommunication Union (ITU), the total number of Internet users in the world reached 3.5 billion at the end of 2016, and the network penetration rate was 47.1% (Roser *et al.*, 2015). Since 2003, Social Networking has emerged rapidly all over the world. Today, it has created many myths and is regarded as the second wave of the Internet with the rise of friendster.com, Orkut.com, Ryze.com, tribe. Nine out of ten teens aged 13-17 use social media platforms, and most (71%) of them use more than one (CNNIC, 2020). The number of youth Internet users using mobile phones reached 932 million, and the proportion of mobile Internet users has reached 99.2% since 2020 (CNNIC, 2021). The rise of social networking on the Internet goes hand in hand with the high penetration of mobile devices.

The new model of Internet social networking is different from face-to-face communication in real life in four main points: anonymity, invisibility, no geographical restrictions, and non-synchronization in time (McKenna & Bargh, 2000). Many researchers have studied the influencing factors of Internet social services, and it can be seen from numerous studies that the use of Internet social services is mainly related to personality traits such as extraversion, neuroticism, social support, and social anxiety (Durbano & Marchesi, 2016). Some researchers believe that extroverted and sociable individuals are more likely than introverted individuals to use the Internet to maintain relationships with family and friends or to make new friends by frequent use of online chat rooms, expand their social relationships and obtain more social support (Amichai-Hamburger & Ben-Artzi, 2003). It is always believed that neurotic people are shy and anxious, and it is difficult for them to form social relationships in real social situations. They can only socialize in front of computer screens. Hamburger and Ben-Artzi's study found that neurotic individuals are more likely to be lonely (Amichai-Hamburger & Ben-Artzi, 2003). They are also more likely to use social services on the Internet. Individuals with social anxiety are more likely to form close friendships on the Internet, and the formation of such friendships on the Internet will increase the individual's self-confidence and self-efficacy. When in the traditional face-to-face interpersonal communication situation, he or she will be more confident about their social skills. The development of social network objectives but how to use them is affected by individual personality differences. We wonder how the different performance led by individual personality would have effects on upward social comparison and thus the online impulse purchase.

#### Online Impulse Buying

From the perspective of psychology, online consumption behavior is the behavior of people in the virtual space of the Internet when they collect, buy, use, judge, and deal with the services, products, resources, and ideas that they want to meet their needs (Li B.N, 2008). A 2014 study by Merzer found that among 1000 adult Americans, 75% reported having made a purchase on impulse alone. Impulse buying is also apparent among consumers in China and arguably even more serious because of the popularity and convenience of online shopping (Chen, & Zhang, 2015). This article would focus on the online impulse buying raised along with the development of the social network.

Impulse buying is defined as an unplanned, sudden purchase, usually accompanied by cognitive and emotional reactions (Rook, 1987). Weinberg and Gottwald (1982) measured impulsive buying from the three levels of emotion, cognition, and reflection. They say impulse buying is actually a rash, thoughtless and unplanned purchase. Impulsive consumers have very strong emotional activities and lack rational evaluation when consuming. Cobb and Hoyer(1986) believed that the so-called impulse purchase is an immediate, sudden behavior without a prior purchase purpose. Dittmar and Friese (1995,1996) explained consumers' impulsive shopping on the basis of social construction theory. They believe that consumers' purchase is a projection of self-identity. That is, consumers regard products as an extension of themselves. The research results confirm that symbolic and emotional products are indeed easy to cause the impulsive purchase of consumers. Researchers to further explain, consumers in the actual I (herself) in real life and ideal (want to be the kind of person) I perceived that the difference between, will want to borrow mountain products use in self-image to make oneself want to be the kind of person, so for such symbolic products, produces impulsive purchase. For example, males attach importance to autonomy and tend to impulsively purchase instrumental and leisure products, while females attach importance to emotional vent and relationship maintenance and tend to impulsively purchase symbolic and self-expression products. Figure 1 followed below is the decision-making process of impulse purchase (Kim, 2003).

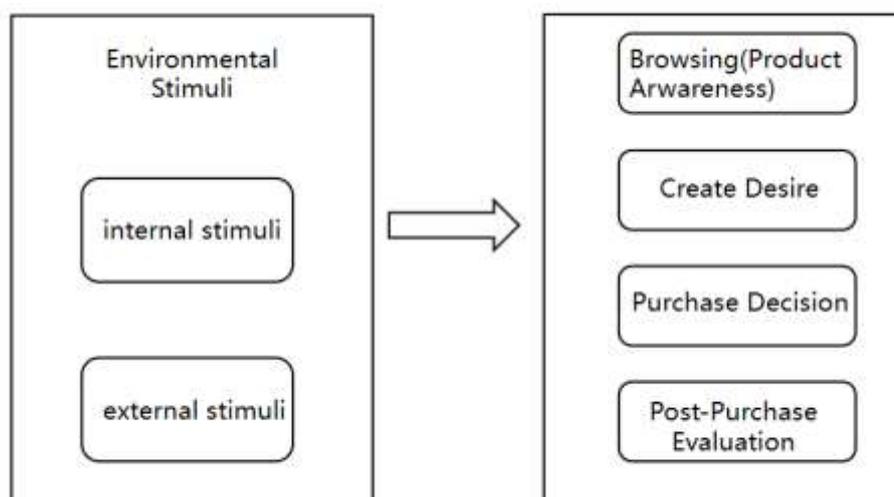


Figure 1: Impulse purchase decision-making process (Kim, 2003).

There have been quite a few researches on impulsive buying. However, most of their study group were adults. As of June 2021, China's Internet users aged 6-19 reached 158 million, accounting for 15.7 percent of the total Internet users (CNNIC, 2021). Our research is designed to focus on the impulse buying existing among the youth (age 15 to 25, defined by World Health Organization). We conducted a questionnaire survey with scales of the Big Five Inventory (John O. P., 1999), Upward Comparison (GIBBONS, F. X., & BUUNK, B. P., 1999), the PANAS Scales (Watson *et al.*, 1988) to figure out the interaction between the personality traits of youth and impulsive buying. We introduced Upward Comparison as the mediation variable and Emotion as the moderator variable.

This paper would fill the research gap in the role of personality traits in impulse shopping among youth, expanding the literature on impulse buying. We are committed to exploring the reasons behind this abnormal shopping and contributing to the targeted improvement of youth mental health. Our study could also provide guidance for mobile social networking marketing.

## LITERATURE REVIEW

### Impulse Purchasing Intention

Stern (1962) gave the early definition of impulse buying and classified impulse buying into pure impulse buying, prompt impulse buying, induced impulse buying, and planned impulse buying. Based on the intrinsic motivation of consumers, Bayley and Nancarrow (1998) divided the types of impulse purchase into a self-confirmed impulse purchase, self-compensation impulse purchase, self-redefinition impulse purchase, and pathological impulse purchase.

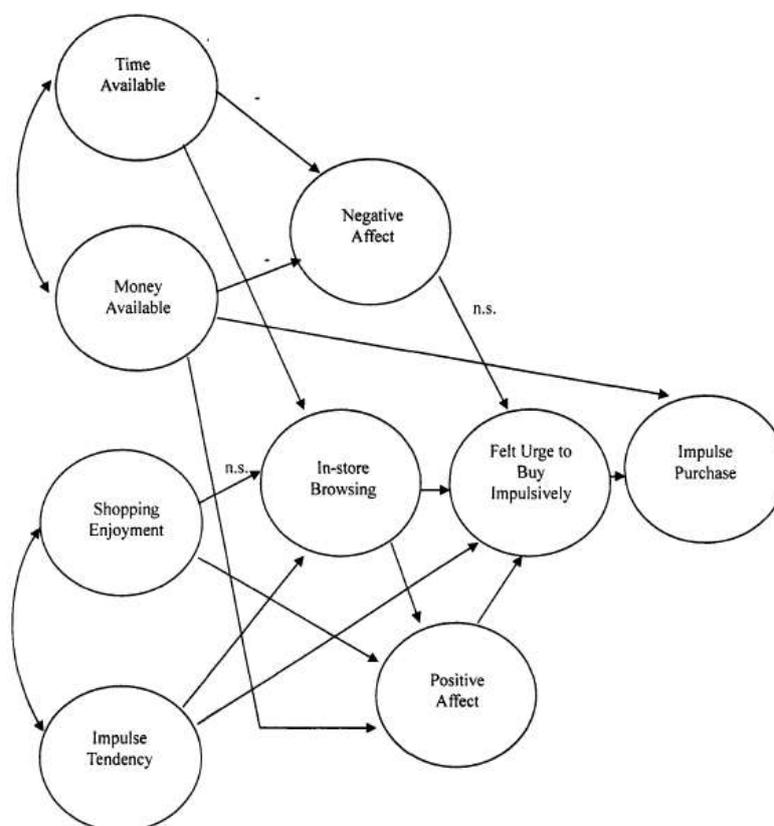
Kollat (1967) pointed out in the research on impulse buying of food that, from the perspective of consumers, the more frequently purchased products (such as various daily necessities and clothing, etc.), the lower the proportion of impulse buying will be. Product decoration refers to the goods on the rack, decoration location, shelf height, etc. Applebaum (1951), Clover (1950), and Katona and Mueller (1955) investigated the frequency of consumers' impulsive purchase behavior under different product categories, different product layouts, and different retail store shelf displays. It confirms the effect of product layout and shelf display on impulse buying.

In addition, the combination of goods can also arouse consumers' desire to buy. Goods are endowed with special meaning, such as representing a way of life, which is very tempting to consumers. Narasimhan, Neslin & Sen (1996) pointed out in the literature that "for impulsive consumers, the time for consideration is relatively short, so some stimulus in the environment, such as a

relatively low price, will increase consumers' perceived value and purchase intention. Agee and Martin(2001) discussed information advertising and pointed out that if manufacturers want to influence consumers' impulse purchases, they need to make consumers aware of the existence of products through advertising information so as to persuade consumers to have demand for the products. The research of D'Astous *et al.* found that TV advertisements can affect consumers' irrational and irregular consumption behaviors, and the amount of exposure to advertisements is significantly positively correlated with consumers' impulsive shopping. We could easily speculate that the development of social networks increased exposure to goods and promoted impulse buying.

Internal stimuli are also significant factors that cause individual impulse buying related to personality (Bratko, Butkovic, & Bosnjak, 2013). Impulse buying can be induced through individuals' tendency to involve in impulse buying, a hedonic need, motives to seek variety and differences, lack of self-control, and a desire to escape from negative feelings. Situational and product-related factors involve a time of shopping (Jeffrey & Hodge, 2007).

Demographics and social-cultural factors, consisting of individuals' gender, age, income, education, culture, and socioeconomic, are also important determinants of impulse buying (Coley & Burgess, 2003; Vohs & Faber, 2007). The youth group has a series of characteristics, such as personalized needs, rebellious spirit, curiosity about new things, and attention to personal privacy. The network provides the youth group with a consumption space without real boundaries, which is very convenient and full of desire consciousness. Therefore, the youth group has consistency with personality traits that cause impulse buying. Figure 2 followed below is the precursor model of impulse buying (Beatty & Ferrell, 1998).



Source: Beatty & Ferrell (1998).

Figure 2: Cause and effect model of impulsive buying

### Upward Social Comparison

Social comparison is an important feature of social life. People need to compare themselves with others in order to better understand themselves and more accurately understand their own abilities and abilities (Festinger, 1954). Upward social comparison and downward social comparison are two common types of social comparison. Upward social comparison occurs when people are compared to those who are perceived to be socially superior in some way, while downward social comparison occurs when individuals compare themselves to those who are socially inferior (Vogel *et al.*, 2014). Social comparison has multiple functions, including satisfying self-enhancement motivation (Suls, Martin, & Wheeler, 2002), enhancing self-esteem (Vogel *et al.*, 2014), regulating emotions and happiness (Taylor & Brown, 1988), evaluating self (Muller & Butera, 2007), etc. More recently, with the emergence of social networking sites (social networks), social comparisons have become ubiquitous, as social networks can provide a large amount of information describing individuals' lives (Sabati & Sarracino, 2019), and because we spend far more time browsing and searching for information online than offline (Wise, Alhabash, & Park, 2010). Considering that checking other people's profiles on social networks has become an increasingly popular activity (Pempek *et al.*, 2009), social networks are considered to be an almost ideal platform for individuals to make social comparisons. Social comparisons on social

networks may be particularly pronounced among younger people (18-29 years old) as they spend more time browsing and searching information online (Pempek *et al.*, 2009).

### MODEL CONSTRUCTION AND RESEARCH HYPOTHESES

#### Research Hypotheses

The formal studies of impulsive buying mostly focused on the external influence factors of impulse buying. The impulse purchase behavior of youth has been overlooked. Because compared with other groups, the youth group has a strong connection with online consumption, whether in the internal level of education, the motivation to pursue new experience and consumption level with certain level requirements, or in the external level of proficiency in the application of payment technology, avoiding the risk of online consumption, we expected that the personality traits of the youth had a significant influence on their impulse buying.

*H1 : The personality traits of the big five trait taxonomy have a significant effect on the youth's impulsive buying behavior.*

As entered the post-industrial period, the popularity of social networks has had a significant effect on the mental health and behavior of youth through upward comparison. We suggest that the upward comparison would have a mediating effect on the interaction of youth personality and impulsive buying.

*H2: The upward comparison mediates the relationship between personality and impulsive buying of the youth group.*

We still introduced emotion as the moderating variable. Impulse buying is emotion-related behavior. When negative emotions occur, individuals are inclined to purchase impulsively and regard this behavior as a way to comfort themselves. In addition, impulse buying can also elevate chronic negative emotions because the purpose of impulse buying is to make someone feel better (Verplanken *et al.*, 2005). Therefore, we tend to figure out the moderating effect emotion has on the relationship between key variables.

*H3: The emotion moderates the relationship between personality and impulsive buying of the youth group.*

*H4: The emotion moderates the relationship between upward comparison and impulsive buying of the youth group.*

#### Conceptual Structure

The conceptual model is illustrated by the following figure 3.

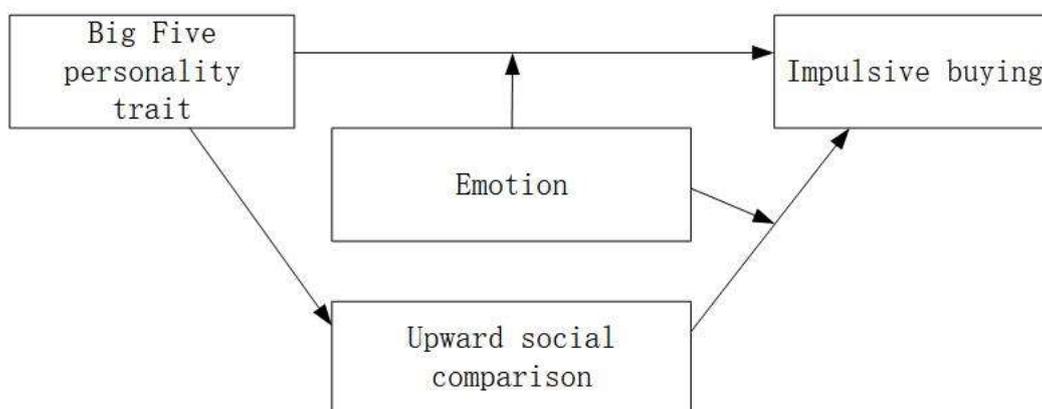


Figure 3: Conceptual model

#### Measurements

Table 1 shows the scale of variables selected in this study.

Table 1: Measurement

Variable	Scale	Source
Impulse Buying Tendency	Impulse Buying Tendency Scale	Verplanken, B. , & Herabadi, A. . (2001). Individual differences in impulse buying tendency: feeling and no thinking. <i>European Journal of Personality</i> , 15.
Personality Traits	The Big Five Inventory	John, O. P. , & Srivastava, S. . (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives.

Upward Social Comparison	Iowa-Netherlands Comparison Orientation Measure	Gibbons, F. X., & Buunk, B. P. (1999). Individual Differences in Social Comparison: Development of a Scale of Social Comparison Orientation. <i>Journal of Personality and Social Psychology</i> , 76(1), 129–142.
Emotion	The PANAS	Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. <i>Journal of personality and social psychology</i> , 54(6), 1063.

### Reliability and validity analysis

Table 2: Reliability analysis

Overall reliability statistics		
Clone Bach Alpha	Standardized term based clone Bach Alpha	items
0.832	0.841	118

As shown in the above table 2, the Alpha value of all items is greater than 0.7 (and the overall Alpha value of each item is less than the revised Alpha value after the deletion of a certain item), and the overall Alpha value of the questionnaire is 0.841. In conclusion, each measurement item has good reliability, and the item design is reasonable without adjustment.

Validity analysis refers to the validity of test results. The coefficient of the KMO test ranges from 0 to 1. The closer its value is to 1, the better the validity of the questionnaire is. Validity test is conducted in this report according to SPSS26.0, and the analysis is shown in Table 3:

Table 3: Validity analysis

KMO and Bartlett tests		
KMO sampling suitability quantity		0.816
Bartlett sphericity test	chi-squared approximation	18795.354
	DOF	6903
	significance	0.000

According to the above results of exploratory factor analysis, the coefficient of the KMO test is 0.816. According to the significance of the sphericity test, the significance of this test is infinitely close to 0. In conclusion, the measurement validity of the questionnaire in this report is good.

### Expected result

We expect that among the dimensions of the five personalities, openness, extraversion and neuroticism have a significant influence on adolescents' impulsive buying behavior, and the other two dimensions are not significant. The upward social comparison is an indirect mediating variable of the relationship between personality and impulsive buying. The interaction would strengthen while the participant in negative emotion during recent one month.

### CONCLUSIONS

In the existing studies, the underlying causes of youth' online impulse spending have been neglected. Our research expands the application of the Big Five Personality Theory in youth groups. We explore the internal cause and mechanism of youth impulsive buying behavior, providing theoretical guidance for the marketing of social network platforms.

### ACKNOWLEDGMENT

Generous financial support was provided by the National Natural Science Foundation of China [grant numbers 71904043, 71872061, 71702045], Social Science Foundation of Jiangsu Province (18TQC002), the Key Program of NSFC-FRQSC Joint Project (NSFC No. 72061127002, FRQSC No. 295837), and Fundamental Research Funds for the Central Universities [grant numbers B210207008].

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## Scares and Stocks: Evidence from Twitter Sentiments During Covid-19

(Work in Progress)

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### ABSTRACT

This paper examines the investor reaction of firm-specific pessimistic sentiment extracted from Twitter messages during the pandemic period due to the Covid-19. We find that Twitter sentiment predicts stock returns without subsequent reversals. This finding is consistent with the view that tweets provide information not already reflected in stock prices during the pandemic period. We investigate possible sources of return predictability with a Twitter sentiment. The results show that Twitter's pessimistic sentiment towards the Covid-19 provides new information about the investor. This information explains about one-third of the predictive ability of Twitter sentiment for stock returns. Our findings shed new light on the predictive value of social media content for stock returns.

*Keywords:* Investor sentiments, Covid-19, Twitter.

“Whenever you consider the economic implications of stock prices, you want to remember three rules. First, the stock market is not the economy. Second, the stock market is not the economy. Third, the stock market is not the economy (...). The relationship between stock performance – largely driven by the oscillation between greed and fear – and real economic growth has always been somewhere between loose and nonexistent”.

——Paul Krugman (2020)

### INTRODUCTION

By February of 2020, the coronavirus 2019 (COVID-19) pandemic had set in motion a worldwide disruption in economic activity, causing the falling S&P 500 stock market index to react to news of the disease by losing 33.7% of its value in one month. As the world suffered from the worst economic crisis since the Great Depression (Baldwin and Weder di Mauro 2020a, 2020b, Bénassy-Quéré and Weder di Mauro 2020, Coibon et al. 2020), the reaction of stock markets raises serious concerns. Since the beginning of the crisis, stock prices seem to be running wild. They first ignored the pandemic, then panicked when Europe became its epicenter. Now, they are behaving as if the millions of people infected, the 400,000 deaths and the containment of half the world's population will have no economic impact after all.

### LITERATURE REVIEW

Emerging literature subsequently explored the impact of the COVID-19 pandemic on equity markets (e.g., Cox et al., 2020; Baker et al., 2019; Gormsen and Koijen, 2020) and the debt markets (e.g., Haddad et al. 2020). However, the causal impact of COVID-19 on investor sentiments has not been formally examined and understood. Barclay (2019)'s report shows that people feel stressed and anxious when faced with financial and investment terminology, compared to neutral words. For instance, investment terms were shown to be particularly stressful, with 'stockbroker,' 'asset management,' and 'investment risk' evoking the slowest response times and therefore being the most likely to provoke anxiety. This effect is most pronounced for those who already self-report as being financially anxious, with this cohort of participants taking the longest to respond. An important question is whether investors' fears on the diseases really have an impact on the investment behavior in stock markets. It remains unclear whether investors' sentiments increase or decrease the investment performance for purchasing or selling a stock, particularly in different markets with the opposite attitudes towards the pandemic COVID-19 (e.g., USA and China).

The aim of this paper is to provide insights into the investors' sentiments and the informational role of social media and enhance our understanding of how social media can best be employed as part of an investment strategy. Bollen et al. (2011) provide evidence that the public mood extracted from Twitter predicts daily aggregate stock returns. However, we still know little about the information content of firm-specific Twitter sentiment, especially when investors' scare raised from such a pandemic COVID-19. Our study attempts to shed new light on this issue.

## IDENTIFICATION STRATEGY

We use Bloomberg's firm-specific Twitter sentiment calculated using tweets from the overall Twitter and StockTwits that Bloomberg classifies as being about a given company. Bloomberg uses supervised machine learning algorithms that, for example, identify financial tweets about Apple, determine if the particular tweet is positive, negative, or neutral, and assign it a confidence score. A firm's daily Twitter sentiment is derived from its story-level sentiment and associated confidence scores in the last 24 hours. The sentiment values are released every morning before the stock market's open during the pandemic COVID-19. Using Bloomberg's Twitter sentiment data allows us to contribute to the literature on the informational content of Twitter messages without doing a daunting and potentially subjective analysis of tweet content. This makes it feasible to examine the predictive content of Twitter sentiment for a large number of individual firms over a long sample period. In addition, using Bloomberg's Twitter sentiment makes our study replicable and transparent.

Bloomberg uses a suite of supervised machine learning methods for social media sentiment analysis. First, Bloomberg lets human experts manually process a large set of tweets. Experts examine the language in a given tweet about a company to determine if the tweet is positive, negative, or neutral. The labeling is based on the question, "If an investor having a long position in the security mentioned were to read this news or tweet, would he/she be bullish, bearish, or neutral on his/her holdings?" Bloomberg then feeds the manually classified tweets into machine-learning models that are trained to mimic language experts in analyzing textual information.

Bloomberg computes firm-level daily Twitter sentiment scores using the confidence-weighted average of the past 24 hours' story-level sentiment scores as follows:

$$Scares_{i,t} = \frac{\sum_{k \in P(i,T)} s_i^k c_i^k}{N_{i,T}}, \quad T \in [t - 24h, t] \quad (1)$$

To investigate the impact of Twitter sentiment scores on stock returns, we use daily cross-sectional regressions similar to those in Fama and MacBeth (1973). Specifically, we first run cross-sectional regressions for each day and then report the time-series averages of the daily coefficient estimates and the corresponding t-statistics. The t-statistics are robust to heteroskedasticity and autocorrelation. Tetlock (2011) uses a similar method to investigate the impact of firm-specific news on stock returns. The regression specification is:

$$Return_{i,t} = a + bScares_{i,t-1} + \sum_{k=1}^5 c_k Return_{i,t-k} + Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

where  $Return_{i,t}$  is the holding period return of stock  $i$  from market open on day  $t$  to the open on the next trading day.  $Scares_{i,t-1}$  is the Twitter sentiment scores of stock  $i$  on day  $t-1$  during the Covid-19 period. As discussed above,  $Scares_{i,t-1}$  measures the sentiment between day  $t-1$  and day  $t$  during the pandemic COVID-19. The coefficient of  $Scares_{i,t-1}$  is our main parameter of interest.

Our work contributes to the small but growing literature in corporate finance about the impacts of the pandemic COVID-19 on investors' sentiments and stock markets. Our study will provide empirical evidence of a causal relationship between investors' sentiments and the volatility of stock markets performance. This study adds to the ongoing debate over whether and how public opinion through social media impacts capital markets. Due to the rapid development of textual analysis techniques, a growing literature attempts to directly measure investor sentiment by analyzing communications of those who are commenting on stocks. This study led some light on the technical use of textual analysis in behavioral finance.

## SAMPLE

We analyze Twitter sentiment for the S&P 500 component stocks. We randomly select 29 stocks from the S&P 500 components. Bloomberg integrated Twitter fed into its platform in April 2013 and started releasing Twitter sentiment data in January 2021. Our sample period is from March 2020 to December 2020 and contains 213 trading days. In total, we have 6,177 stock-day observations and 5,592 non-missing observations of firm-specific Twitter sentiment.

## PRELIMINARY RESULTS

In Table 1, we present summary statistics for our full sample. The panel shows that the average Scares measured by Twitter sentiment is -0.072, indicating that, on average, the content of tweets concerning members of the S&P 500 index is slightly negative. The mean raw return is about 0.1 basis points, consistent with the general upward trend in the stock market during our sample period. The mean values of positive tweets, negative tweets, volatility, and the bid-ask spread are 24.713, -28.648, 31.619, and 0.031, respectively. All variables show large variation. This suggests that negative tweets are associated with higher contemporaneous volume, volatility, spread, and firm size than positive tweets. This is consistent with the well-documented finding that bad news tends to have a larger effect on stock return volatility than does good news (e.g., Engle and Ng, 1993).

Table 1: Summary statistics.

Variable Name	Obs	Mean	SD	Min	Median	Max
Scares	5592	-0.072	0.069	-0.900	-0.049	-0.002
TwtrPubCnt	6177	507.777	958.440	3.000	136.000	17825.000
TwtrPosSentCnt	5820	24.713	59.228	1.000	9.000	1676.000
TwtrNegSentCnt	5592	-28.649	70.298	-3081.000	-9.000	-1.000

Volatility	6177	31.619	11.698	20.570	27.760	82.690
Raw Returns	6177	0.001	0.030	-0.238	0.001	0.243
ReturnontheSP500Index	6177	0.001	0.023	-0.120	0.003	0.094
Bid-ask_Spread	6177	0.031	0.023	0.005	0.024	0.333

Table 2 reports the regression estimates. As discussed above, the raw return is computed from the current day to the following day as a daily return. As seen in column 1, the coefficient estimate on  $Scares_{i,t-1}$  is negative and but not significant. When we adjust the raw return by deducting the market return, the coefficient estimate on  $Scares_{i,t-1}$  is negative and statistically significant, as seen in column 2. On average, the adjusted stock return over the next 24h for firms with the most negative Twitter sentiment (  $Scares = 1$  ) is about 27.2 basis points higher than the return for firms with the most negative Twitter sentiment (  $Scares = -1$  ).

Table 2: Main regressions on scares and stock returns.

VARIABLES	(1) Raw Return	(2) Risk-adjusted Return
$Scares_{t-1}$	-0.0029 (-0.48)	-0.0085** (-2.05)
<i>Volatility</i>	-0.0007*** (-13.70)	-0.0001*** (-4.54)
<i>Bid_ask_Spread</i>	0.2041*** (8.25)	0.1341*** (8.06)
<i>Size</i>	0.0000 (0.10)	0.0000 (0.71)
Constant	0.0161*** (12.39)	0.0009 (0.98)
Observations	5,591	5,591
R-squared	0.033	0.012

t-statistics in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

The predictive power of Twitter sentiment for individual stock returns may be explained by its information content. If Twitter sentiment contains useful fundamental information about stocks, its effect on returns should be permanent. Mao et al. (2015) find that the effect of market-wide Twitter sentiment on stock indices is permanent. On the other hand, if Twitter sentiment simply reflects the sentiment of uninformed traders, the impact of Twitter sentiment on stock returns should be reversed over the next few trading days. We test whether the negative influence of Twitter sentiment on returns is temporary or permanent by including four additional lags of Twitter sentiment in the model in Eq. (2). We run regressions for both raw returns and risk-adjusted returns. Table 3 shows that controlling for lags of Scares measured by Twitter sentiment has little effect on the predictive value of Twitter sentiment for stock returns.

Table 3: Main regressions on lagged scares and stock returns.

VARIABLES	(1) Raw Return	(2) Risk-adjusted Return
$Scares_{t-1}$	-0.0074 (-0.82)	-0.0057 (-0.94)
$Scares_{t-2}$	0.0006 (0.07)	-0.0028 (-0.43)
$Scares_{t-3}$	-0.0062 (-0.65)	0.0083 (1.28)
$Scares_{t-4}$	0.0156 (1.62)	0.0047 (0.73)
$Scares_{t-5}$	-0.0182** (-2.06)	-0.0026 (-0.43)
<i>Volatility</i>	-0.0007*** (-12.09)	-0.0002*** (-4.21)
<i>Bid_ask_Spread</i>	0.2023*** (7.23)	0.1388*** (7.37)
<i>Size</i>	0.0000	0.0000

	(0.28)	(0.66)
Constant	0.0156***	0.0011
	(10.06)	(1.07)
Observations	4,470	4,470
R-squared	0.034	0.013

t-statistics in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

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## Understanding User Engagement in Online Communities during COVID-19 Pandemic: Evidence from Sentiment and Semantic Analysis on YouTube

(Work in Progress)

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### ABSTRACT

Since the outbreak of COVID-19, the pandemic has changed the lives of many people and brought dramatic emotional experiences. Among many social media platforms, YouTube saw the most significant growth of any social media app among American users during the pandemic, according to the Pew Research Center on 7<sup>th</sup> April 2021. Exposure to COVID-19 related news can have a significant impact on user engagement on social networks. Different news may trigger different emotions (i.e., anger, anticipation, disgust, fear, joy, sadness, surprise, or trust), and a user may engage differently in response to the news. On YouTube, user engagement is manifested through actions such as liking, disliking, commenting, or sharing videos. During the pandemic, many users provide constructive comments that are encouraging, respectful, and informative to support each other. We applied sentiment analysis in the study to investigate different emotions and applied semantic analysis to investigate positive appraisal (i.e., encouraging, respectful, and informative) to identify salient factors that can motivate user engagement. The findings of the work shed light on how social network platforms could encourage constructive comments to help people provide emotional support to each other during pandemics through using positive appraisal in online news comments.

The first research objective is to study the impact of sentiment valence of different emotions on people's liking of news comments. News about COVID-19 on social networks may provide valuable information but also bring about public panic. In response to this COVID-19 related news, reviewers expressed their feelings by clicking the like, dislike buttons to the video and comments, or writing some comments under the video on YouTube. Some positive news was followed by comments expressing their anticipation, joy, and trust, while negative news might trigger sadness, fear, disgust, or anger. Our research focuses on sentiment analysis of news titles and the comments following each video. News title provides important information about the video, showing the summary of the video and allowing people to get a first glimpse of the content of the video. Through sentiment analysis of title and comments, correlations could be found between title/comments sentiment and user engagement.

The second research objective is to investigate the impact of comments' positive appraisal (i.e., encouraging, respectful, and informative content) on user engagement. The informative comments under the negative news have significant implications for the audience. They can be considered as a complement or judgment of the video content. Encouraging and respectful comments also help people build good conversations online. Our research focuses on semantic analysis of news titles and comments based on the three dimensions of positive appraisal and analyzes their impacts on user engagement to like the corresponding comment. We discuss the correlation between video title sentiment and the positive appraisal followed in the comments of the video to provide good conversations on the platform.

A group of 38,085 online comments was collected from more than 400 different publishers from January 1<sup>st</sup> to January 30<sup>th</sup>, 2021, on YouTube. The dataset contains the most-viewed videos that were related to at least one of the following search queries: coronavirus, COVID-19, pandemic, or vaccine. NRC lexicon is adopted in the sentiment analysis to identify different emotions in titles and comments of the video. We adopt the topic modeling method and build a classifier from the Yahoo News Annotated Comments Corpus to identify constructive online comments for specific topics. We also measure inter-annotator agreements and compare the reliability of manual annotation and the classifier. We find that longer titles and sad emotions can obtain more likes on the comments of COVID-19 related news. During the pandemic, people tend to show their support when they find others are quite sad. We also expect to see correlations between some positive appraisals and user engagement.

*Keywords: Sentiment analysis, user engagement, COVID-19, YouTube*

## INTRODUCTION

Since the outbreak of the COVID-19, many people have had to stay at home during the lockdown, spending more time on the internet. YouTube is one of the biggest video platforms in the world for people to obtain information about the pandemic. Many media companies also have their official accounts on YouTube to enhance user engagement in the online platform. User engagement can be manifested through actions such as liking, disliking, commenting, or sharing videos. While semantic analysis on polarities, such as positive, negative, or neutral emotions on social media, were investigated (Saragih & Girsang, 2017; Schumaker *et al.*, 2012; Salehan & Kim, 2016), the majority of the literature did not look into the impacts of specific emotions in comments (Chen *et al.* 2017, Khan 2017) on user engagement. During the pandemic, news videos cause various emotional responses during the early few weeks after the outbreak of the COVID-19 (Haron & Rizvi 2020). Therefore, the first research questions of this study are:

*RQ1: How will specific emotions lead to more readership of video/comments on YouTube?*

During a pandemic, users may provide constructive comments that are encouraging, respectful, and informative to support each other on a social network platform. The second research question is:

*RQ2: How will positive appraisals lead to more readership of video/comments on YouTube?*

## HYPOTHESIS AND RESEARCH MODEL

In the model, we will consider different emotions of sentiment in the text of titles and reviews besides general sentiment (i.e., positive, negative, or neutral). Polarity refers to sentiment direction, which can be positive, negative, and neutral in the results. The research model is illustrated as the following (see Figure 1):

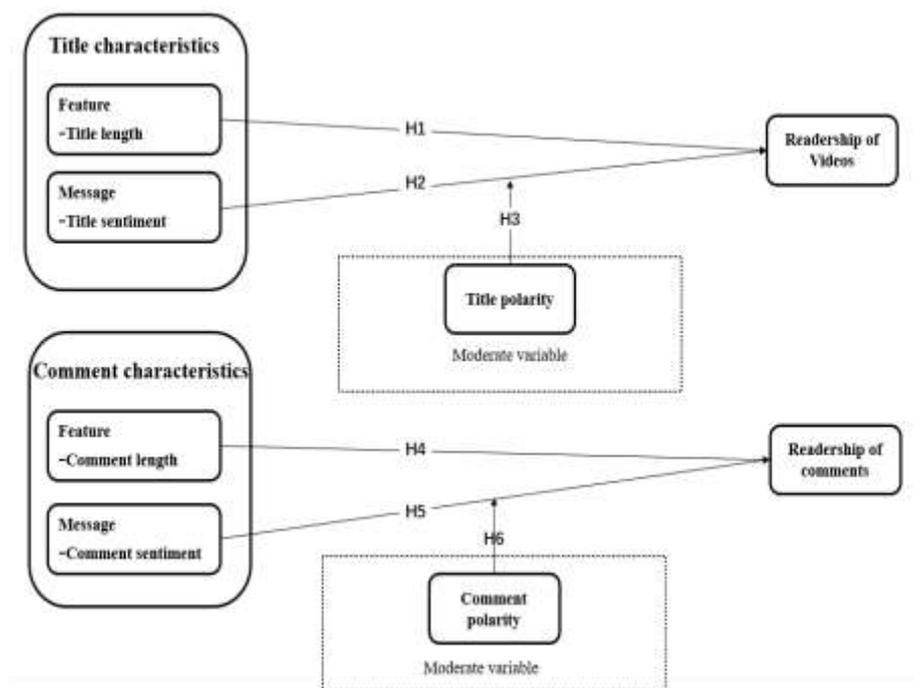


Figure 1: Research model

### Hypotheses Development

#### *Effect of emotions on readership of videos*

A short title usually does not contain enough information. Some examples are “Will COVID-19 vaccine passports work?” or “Cahn Health Hour COVID 19 Vaccine Panel”. Compared with short sentences, long sentences provide more information to attract the audience to read. For example, “Health Official Warns 'Wait-And-See Approach' On Covid Vaccine Could Be Deadly.” Therefore, we hypothesize that:

*H1. The length of the title of a review has a positive effect on the readership of the video.*

According to the selective attention perspective, people only have limited attention when they are processing information. The text with stronger emotions can gain more attention and feedback compared to the text with neutral emotions. Therefore, we hypothesize that:

*H2. The larger the total amount of sentiment the title of a video exhibits, the more readership it may receive.*

According to the selective perception theory, people will filter the information because of the people's mental structure. People are more willing to absorb the information that is fixed with their mental structure instead of choosing to believe information that is not meet their mental structure. People are like to read and click likes to the opinion in the news that they are agreed. Therefore, we hypothesize that:

*H3. Title polarity moderates the effect of title sentiment on the readership of the video. The effect will be larger for a positive title than negative and neutral ones.*

#### **Effect of emotions on readership of comments**

The longer comment is more persuasive than the short comment. Longer comments may contain more information, and it is easily empathizing with others, so it also will be considered it is more helpful than short content. For example, short comments only include a general idea about the news, such as “nice” or “Good news, sir.” For longer comments, for example, “Pfizer's figure of 95 % is fake too, figures were manipulated or omitted in 3rd phase trial, the efficacy is roughly 30 %.”, it gives keyword information like “Pfizer” “fake” and many data to support the idea. Thus, we hypothesize that:

*H4. The length of the comment has a positive effect on the readership of the comments.*

Following similar logic in *H2* and *H3*, we propose that:

*H5. The larger the total amount of sentiment the comment exhibits, the more readership it may receive.*

*H6. Comment polarity moderates the effect of title sentiment on the readership of the video. The effect will be larger for a positive title than negative and neutral ones.*

## **METHOD**

A group of 38,085 online comments from more than 400 different publishers was collected from YouTube. The videos in this dataset are between January 1st, 2021, and January 30th, 2021. The dataset contains the most-viewed videos that were related to at least one of the following search queries: coronavirus, covid-19, pandemic, vaccine. We selected videos whose total comments likes were no less than 1 to ensure there is a minimum number of likes accumulated for the comments. The final sample consisted of 10,860 comments with 201 videos. Semantic analysis is applied to investigate eight emotions contained in each video title and its comment based on NRC Emotion Lexicon. Sentiment polarity as well sentiment are calculated

Polarity = positive sentiment + negative sentiment.

The positive sentiment has a range from 1 to 5, and the negative sentiment has a range from -1 to -5, so the polarity will range from -4 to 4. The other method to assess the sentiment of the information is to calculate the total amount of sentiment in each information. The negative sentiment output is a negative number. We calculate the absolute value of it and then use the number to add up with the positive number. The following is our formula of the readership, the equation 2:

Sentiment = (positive sentiment – negative sentiment) – 2

The positive sentiment has a range from 1 to 5, minus the negative sentiment, which has a from -1 to -5, so the total sentiment will have a range of 2 to 10. To normalize it, we minus two from (positive sentiment – negative sentiment). Finally, it will have a range from 0 to 8 (Salehan and Kim 2016).

The length of the title and comments was obtained by calculating the characters of the information. Longevity was measured by counting the number of days since the review was created. The readership of a video's title is measured by the total number of likes and dislikes in a video. The agreement of a video's comment was measured by dividing the number of likes by the total number of comments' likes under each video to reduce the problem of a low number of likes per comment due to a low number of total video comments.

## **DATA ANALYSIS AND RESULTS METHOD**

We used negative binomial regression to test our first model because our dependent variable follows a negative binomial distribution. Descriptive statistics, correlation analysis, and regression coefficients were provided in Appendix.

Table 1: Hypotheses Testing Result

1.	H1: Title Length → Readership	-0.164 <sup>***</sup>	Supported
2.	H2: Title Sentiment → Readership	-0.163 <sup>***</sup>	Supported
3.	H3: Title polarity moderates the effect of title sentiment.	-0.126 <sup>***</sup>	Supported
4.	H4: Comment Length → Readership	0.079 <sup>***</sup>	Supported
5.	H5: Comment Sentiment → Readership	-0.12	Not supported
6.	H6: Comment polarity moderates the effect of comment sentiment	0.016	Not supported

\*\*\* p < 0.001 \*\* p < 0.01 \* p < 0.5

From the descriptive statistics in Table A.1, we can find that the most salient emotions in title sentiment are anticipation (mean=0.26), trust (mean=0.24), and fear (mean=0.17). The most salient emotions in content sentiment are trust (mean=0.57), anticipation (mean=0.47), and fear (mean=0.36). As shown in Table 1, H1-H4 is supported. However, H5 on general comment sentiment and H6 is not supported. Table A.4 shows that among all specific emotions, sadness was found to be a significant predictor of the number of likes for comments among all eight emotions ( $b = -0.047$ ,  $p < 0.05$ ). We could also find that the moderation effect of polarity.

### DISCUSSION AND CONTRIBUTIONS

We made contributions through investigating more specific emotions instead of general sentiment, which can only address positive, negative, and neutral polarity. The study provides the value to investigate different dimensions of sentiment in a different context. Since the pandemic brings a dramatic change to people's lives, it may change the distribution of different emotions on the internet. People tend to be more supportive of comments which are sad and try to support each other during this difficult time. Other emotions are not as salient as sadness in the context of COVID-19 at its very beginning. The moderating effect of polarity of emotion also indicates that people tend to provide sympathetic responses to others and to seek resonance.

### LIMITATIONS AND FUTURE WORK

There are several limitations of the study. First, the sample of the video includes only one month's data in January 2021. Second, there isn't any information about the replies to each comment thread in the data. Therefore, the data analysis does not consider the interactions of sequential comments. Third, the content of the video is not considered at this stage. In the future, more comprehensive data with different comment threads will be collected, and panel data analysis will be adopted. The content of the video should also be taken into consideration in future research.

To answer the second research question, we adopt the topic modeling method and build a classifier from the Yahoo News Annotated Comments Corpus to identify constructive online comments for specific topics. We also measure inter-annotator agreements and compare the reliability of manual annotation and the classifier. In a pretest, we found that positive appraisal may affect user engagement in a different way on different topics, i.e., COVID-19 and vaccine.

In conclusion, we confirm previous findings that longer titles and comments could attract more likes. The general sentiment (being positive, negative, or neutral) in the video title is salient to attract users. However, general sentiment for comments is not significantly correlated with likes. Sadness emotion in the comments can trigger more likes to the comments. During the pandemic, people tend to show their support when they find others are quite sad. We also expect to see correlations between some positive appraisals and user engagement in different topics.

### ACKNOWLEDGMENT

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**APPENDIX A:**  
Table A.1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
title_length	10838.00	11.49	3.12	5.00	19.00
title_positive	10838.00	1.14	0.40	1.00	3.00
title_negative	10838.00	-1.43	0.71	-4.00	-1.00
title_polary	10838.00	-0.29	0.87	-3.00	2.00
title_positive_dummy	10838.00	0.11	0.31	0.00	1.00
title_sentiment	10838.00	0.58	0.76	0.00	3.00
likes	10838.00	2524.00	4193.84	13.00	25716.00
dislikes	10838.00	627.53	1977.39	4.00	20509.00
totle_likes	10838.00	3151.53	4924.82	78.00	29447.00
comment_count	10838.00	986.67	1465.14	16.00	11679.00
comment_positive	10838.00	1.59	0.76	1.00	5.00
comment_negative	10838.00	-1.62	0.91	-5.00	-1.00
comment_sentiment	10838.00	1.21	1.18	0.00	7.00
comment_polary	10838.00	-0.02	1.20	-4.00	4.00
review_neutral	10838.00	0.41	0.49	0.00	1.00
comment_length	10838.00	17.38	18.59	1.00	175.00
comment_likes	10838.00	20.70	98.61	0.00	3473.00
title_totle_like	10838.00	1971.86	2923.55	41.00	14799.00
comment_anger	10838.00	0.23	0.54	0.00	6.00
comment_anticipation	10838.00	0.47	0.85	0.00	9.00
comment_disgust	10838.00	0.18	0.47	0.00	6.00
comment_fear	10838.00	0.36	0.79	0.00	20.00
comment_joy	10838.00	0.33	0.72	0.00	9.00
comment_sadness	10838.00	0.27	0.61	0.00	6.00
comment_surprise	10838.00	0.23	0.54	0.00	7.00
comment_trust	10838.00	0.57	1.01	0.00	11.00
title_anger	10838.00	0.15	0.40	0.00	2.00
title_anticipation	10838.00	0.26	0.49	0.00	2.00
title_disgust	10838.00	0.09	0.28	0.00	1.00
title_fear	10838.00	0.17	0.40	0.00	3.00
title_joy	10838.00	0.09	0.29	0.00	1.00
title_sadness	10838.00	0.12	0.35	0.00	2.00
title_surprise	10838.00	0.11	0.32	0.00	2.00
title_trust	10838.00	0.24	0.46	0.00	2.00

Table A.2: Correlations

	likes_total_likes	anger	anticipation	disgust	fear	joy	sadness	surprise	trust	log_length	sentiment_neutral	log_longevity
likes_total_likes	1.00											
anger	0.02	1.00										
anticipation	0.01	0.17	1.00									
disgust	0.02	0.55	0.12	1.00								
fear	0.01	0.52	0.26	0.40	1.00							
joy	0.00	0.09	0.55	0.05	0.15	1.00						
sadness	0.01	0.57	0.14	0.51	0.61	0.08	1.00					
surprise	0.02	0.35	0.46	0.20	0.28	0.43	0.26	1.00				
trust	0.01	0.10	0.43	0.08	0.17	0.58	0.09	0.32	1.00			
review_neutral	0.00	-0.16	-0.14	-0.15	-0.17	-0.18	-0.16	-0.14	-0.15			
log_length	0.05	0.26	0.35	0.19	0.31	0.25	0.29	0.24	0.33	1.00		
sentiment_neutral	0.02	0.15	0.11	0.13	0.14	0.13	0.14	0.11	0.11	0.23	1.00	
log_longevity	-0.20	0.03	0.04	0.01	0.10	0.03	0.05	0.02	0.04	0.08	0.03	1.00

Table A.3: Readership of Video

	Coef.	Std. Err.	t	P> t	Beta
log_total_likes					
avg_comment_disgust	-1.66	0.12	-14.24	0.00	-0.12
avg_comment_surprise	-0.91	0.11	-8.19	0.00	-0.08
log_avg_comment_length	-0.30	0.05	-6.01	0.00	-0.07
avg_sentiment_neutral	-0.01	0.01	-0.83	0.41	0.00
log_avg_comment_longevity	0.21	0.01	14.75	0.00	0.15
title_sentiment	-0.21	0.01	-14.65	0.00	-0.12
title_length	-0.06	0.00	-13.31	0.00	-0.13
sentiment_positive	0.12	0.02	4.62	0.00	0.03
log_title_longevity	0.07	0.01	5.92	0.00	0.04

Table A.4: Readership of Comments

	Coef.	Std. Err.	t	P> t	Beta
comment_likes_total_likes					
comment_anger_polarity	0.00	0.00	0.72	0.47	0.02
comment_anticipation_polarity	0.00	0.00	0.92	0.36	0.02
comment_disgust_polarity	0.00	0.00	1.63	0.10	0.04
comment_fear_polarity	0.00	0.00	1.50	0.13	0.03
comment_joy_polarity	0.00	0.00	-1.44	0.15	-0.03
comment_sadness_polarity	0.00	0.00	-2.20	0.03	-0.05
comment_surprise_polarity	0.00	0.00	-0.18	0.86	0.00
comment_trust_polarity	0.00	0.00	-0.05	0.96	0.00
comment_anger_anger_polarity	0.00	0.00	-1.19	0.23	-0.03
comment_anticipation_anticipatio	0.00	0.00	-1.76	0.08	-0.04
comment_disgust_disgust_polarity	0.00	0.00	-1.39	0.17	-0.03
comment_fear_fear_polarity	0.00	0.00	-1.45	0.15	-0.03
comment_joy_joy_polarity	0.00	0.00	1.46	0.15	0.03
comment_sadness_sadness_polarity	0.00	0.00	2.59	0.01	0.06
comment_surprise_surprise_polarity	0.00	0.00	0.91	0.37	0.02
comment_trust_trust_polarity	0.00	0.00	-0.97	0.33	-0.02
review_neutral	0.00	0.00	-0.24	0.81	0.00
log_comment_length	0.00	0.00	7.55	0.00	0.09
sentiment_neutral	0.00	0.00	1.09	0.28	0.01
log_comment_longevity	-0.01	0.00	-25.53	0.00	-0.30
title_sentiment	0.00	0.00	0.56	0.58	0.01
title_length	0.00	0.00	-2.60	0.01	-0.05
sentiment_positive	0.00	0.00	3.90	0.00	0.05
log_title_longevity	0.00	0.00	-0.91	0.36	-0.01