Cheng, J.H., & Jheng, Z.H. (2024). The influence of green innovation on sustainable transition in supply chains - Green knowledge management as a moderator. In Li, E.Y. *et al.* (Eds.) *Proceedings of The International Conference on Electronic Business, Volume 24* (pp. 679-683). ICEB'24, Zhuhai, China, October 24-28, 2024

The Influence Of Green Innovation On Sustainable Transition In Supply Chains – Green Knowledge Management As A Moderator

Jao-Hong Cheng [1,*]
Zong-Heng Jheng [2]

*Corresponding author
[1] Professor, National Yunlin University of Science and Technology, Douliu, Taiwan, jhcheng@yuntech.edu.tw
[2] PhD Student, National Yunlin University of Science and Technology, Douliu, Taiwan, D10623001@yuntech.edu.tw

ABSTRACT

This paper presents a research model to examine the factors influencing the sustainable transition developed and implemented in green supply chains. In this study, we examine how attitude toward green innovation affects sustainable transition for green supply chains, and how this association is affected by green knowledge management. Data are collected from 318 manufacturing firms that are among the leading 2500 Taiwanese manufacturing firms listed on the China Credit Information Service Center. Our results show that green innovation was found to be positively associated with sustainable transition. In addition, green knowledge management is positively associated with the interaction between green innovation and sustainable transition in green supply chains.

Keywords: Green innovation, green knowledge management, sustainable transition.

INTRODUCTION

Sustainable transition has increasingly become an important issue for the green supply chains. For environmental sustainability, the traditional manufacturing and production transformation "green" is necessary, driving into a green industry transition is one of the key points for firms (Granco, G et al., 2019). Circular economy is a conceptual for green and sustainable operating which means a system relying on a business model which emphasizes reducing reusing, recycling, and recovering materials during the production, distribution, and consumption process. (Ali Q et al., 2022). A primary objective is to facilitate effective sustainable transition among supply chains (Sajad Jahangiri et al., 2023). The purpose is related with one or multiple firms' collaboration and information sharing which whole a supply chain impacts industry transformation (Jao-Hong Cheng et al., 2016; Wang, C. et al., 2020).

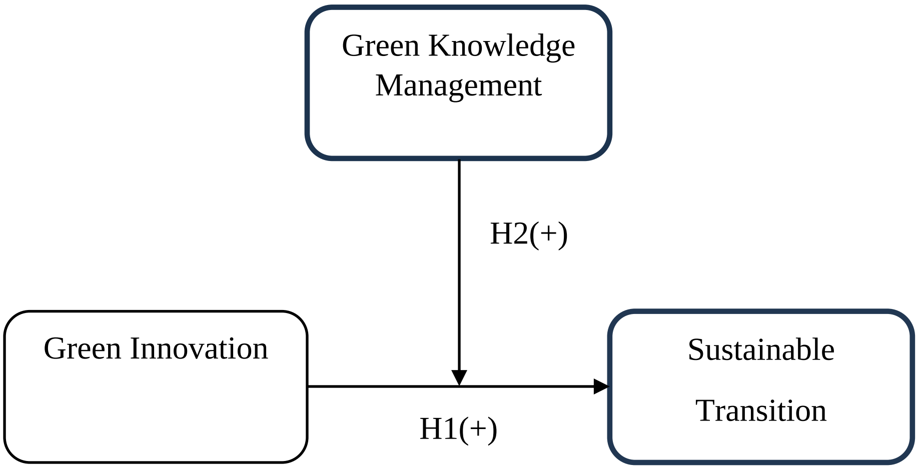
To achieve the advantages of sustainable transition, it is of strategic importance for the manufacturing firms to understand those factors that affect the sustainable transition behaviors of their partners. Industry transformation means a system distinguished some processing and mechanism different before (Elzen, B et al., 2004). In past decade, to develop a sustainable transition firm is an import issue (Grin, J et al., 2010). Green innovation is one of key factor to drive sustainable transition for firms (Salim Karimi Takalo, et al., 2021), and a firm degree of digitalization can enhance sustainable transition (Di Vaio et al., 2021; Thanh Tiep Le et al., 2024), and some research point out green knowledge management raised green innovation (Muhammad Usman Shehzad et al., 2023). However, less research discusses with how enhanced green innovation to sustainable transition. Thus, we provide this research model in this study.

To address the important issue of sustainable transition improvement in the context of green supply chains, a research model is developed in this study for the investigation of factors influencing inter-organizational sustainable transition. To verify this research model, we first examine how the green innovation affects its attitude toward sustainable transition. Then, we through a moderate factor of green knowledge management to test how it influenced the relationship between green innovation and sustainable transition.

In the following sections, Section 2 presents theoretical framework and hypothesis development. The data collection method and research design are described in Section 3, and the research results are presented in Section 4. Finally, Section 5 provides a discussion.

THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

Figure 1 depicts the proposed positive association between green innovation and sustainable transition, moderated by one factor: green knowledge management. Two hypotheses were tested with respect to this model. Each hypothesis is indicated by the letter H and a number. The arrows indicate the hypothesized relationships, and the plus signs indicate positive relationships respectively.



Source: This study.
Figure 1: The Research Model.

In a supply chain, green innovation means that improvements pertaining to eco-friendly goods or procedures for hardware or software, green innovation is in manufacturing process which included energy conservation technology, pollution avoidance technology, trash recycling technology, sustainable product design (Thanh Tiep Le et al., 2024). Sustainable transition is a development processing which three tiers are separated on ranking the practices, assessing the current status, and developing a management plan (Sajad Jahangiri et al., 2024). It can evaluate the process and identify the priority what to green in manufacturing process. Thus, it is reasonable to propose that green innovation improves sustainable transition. It is thus hypothesized that:

Hypothesis 1: Green Innovation is positively related to sustainable transition.

According to the study of Le (Thanh Tiep Le et al., 2024), digitalization plays a mediator which can enhance green innovation in green supply chains, and indicates the firm digitalization degree has a positive effect on green innovation. Green entrepreneurial orientation adopts green knowledge management to exploratory green innovation (Muhammad Usman Shehzad et al., 2023), that concludes green knowledge management is a pivot role in green innovation. Above Accordingly, we know green innovation which can explore from green knowledge management. Thus, green knowledge management be a moderating factor in this study to discover the green innovation drives sustainable transition, it is hypothesized that:
Hypothesis 2: Green knowledge management increase the positive effect of green innovation on sustainable transition.

RESEARCH METHOD AND DATA COLLECTION

This empirical study targeted the top 2500 manufacturing enterprises in Taiwan selected from the directories of the 2022 Chinese Credit Information Service (Taiwan's leading credit company). We sought to choose respondents who were expected to have experience in the operation and management of the inter-organizational relationships between their manufacturing firm and its suppliers or subcontractors.

Content Validity

To develop the survey instrument, pools of items are identified from this literature in order to measure the constructs of this research model. All measures of this survey instrument were developed from the literature. The expressions of these items are adjusted, where appropriate, to the context of marine transportation logistics. The items measured on a seven-point Likert scale, ranging from 'strongly disagree' (1) to 'strongly agree' (7).

Pre- and Pilot-Tests

To improve the content and appearance of the 15-item questionnaire, it was pretested on a sample comprising four academic researchers and four Ph.D. students. Then, several managers in the supply chain industry were contacted to help with pilot-testing the instrument. The respondents were asked to complete the questionnaire and provide comments on the wording, understandability, and clarity of the items in addition to the overall appearance and content of the instrument. The responses suggested that all of the statements be retained with only minor cosmetic changes needed. After a further review by two other academic researchers, the instrument was deemed ready to be sent to a large sample to gather data for testing our research model.

Data Collection and Respondents' Profiles

A total of 318 usable responses were collected from function managers or other members of the senior management teams, such as general managers, vice presidents, or CEOs. This resulted in a sample size of 318 with a response rate of 12.7%. Table 1 shows the demographic and characteristic profiles of the participating firms.

Table 1. Profile of the participating manufacturing firms

Demographic profile		Number of firms	percentage
Industry type	N=318		
Electronics/communication		81	25.6
Optical and precision instruments industry		23	7.3
Transportation equipment and parts industry		19	6
Electrical machinery/machinery and equipment		28	8.8
Non-metallic mineral products		17	5.4
Basic metal industry and metal products industry		47	14.8
Chemical materials and products industry, rubber and plastics		45	14.2
Agricultural products and food industry		26	8.2
Textile industry		19	6
Others		13	4
Total sales revenue (New Taiwan $)	N=318		
Below $1 billion		47	15.1
$1.1 billion to below $2 billion		39	12.4
$2.1 billion to below $3 billion		39	12.4
$3.1 billion to below $4 billion		17	5.4
$4.1 billion to below $5 billion		35	11.1
$5.1 billion to below $10 billion		21	6.7
$10.1 billion to below $20 billion		25	8
$20.1 billion to below $50 billion		62	19.7
$50.1 billion and above		29	9.2
Years of establishment	N=318		
Less than 5 years		32	10.1
6-10 years		69	21.8
11-15 years		27	8.5
16-20 years		32	10.1
21-25 years		43	13.6
26-30 years		22	7
Over 31 years		91	28.8
Position of respondent	N=318		
Top managers		215	67.6
Position of respondent		103	32.4

Source: This study.

RESEARCH RESULTS

Structural equation modeling (SEM) with LISREL 8.54 (Joreskog & Sorbom, 1993) was used to test and analyze the hypothesized relationships of the research model. SEM aims to examine the interrelated relationships between a set of posited constructs simultaneously; each construct is measured by one or more observed items (measures). SEM involves the analysis of two models: a measurement (or confirmatory factor analysis) model and a structural model (Anderson & Gerbing, 1988). The measurement model specifies the relationships between the observed measures and their underlying constructs, which allowed to inter-correlate, and the structural model specifies the posited causal relationships among the constructs. This paper tested interaction effects by following the procedure used by previous studies (e.g., Cortina, Chen, & Dunlap, 2001; Gielnik, Zacher, & Frese, in press; González-Benito, 2007; Kroes & Ghosh, 2010; Lewin & Sager, 2009; Mathieu, Tannenbaum, & Salas, 1992; Rapp, Ahearne, Mathieu, & Schillewaert, 2006). Specifically, two composite latent variables were used to create a third interaction variable, which was then used to test the impact of the interaction effects (Kroes & Ghosh, 2010).

Assessment of The Measurement Model

This study performed exploratory factor analysis using principal axis factoring to ascertain whether our items loaded onto a common latent factor. The measurement model specified for the research model was assessed to determine the extent to which the observed measures (surveyed items) were actually measuring their corresponding constructs. The 15 items of the survey instrument were analyzed to assess their dimensionality and measurement properties, and they all loaded significantly and substantially on their underlying constructs, providing evidence of convergent validity. Using an exploratory factor analysis, all of the items were found to perform well and were thus retained in the model, as shown in Table 2, and the inter-correlations between the four constructs of the structural model in Table 3.

Table 2. Convergent validity

	Factor Loading	S.E.	t Value	P	SMC	AVE	CR
G1	0.750	0.046	7.162	***	0.563		
G2	0.517	0.052	8.154	***	0.267	0.452	0.761
G3	0.814	0.50	7.821	***	0.663		
G4	0.562	0.056	7.850	***	0.316		
KM1	0.584	0.121	16.482	***	0.341		
KM2	0.739	0.133	16.927	***	0.546		
KM3	0.758	0.143	18.559	***	0.575		
KM4	0.772	0.135	17.886	***	0.596	0.463	0.856
KM5	0.654	0.119	16.369	***	0.428		
KM6	0.673	0.133	16.730	***	0.453		
KM7	0.550	0.128	17.088	***	0.303		
ST1	0.760	0.270	2.566	**	0.578		
ST2	0.613	0.350	6.023	***	0.376	0.418	0.739
ST3	0.613	0.320	5.439	***	0.376		
ST4	0.584	0.320	8.277	***	0.341		

** and *** denotes significance at α =0.01 and 0.001.

Source: This study.

Table 3. Discriminate validity

Construct	(1)	(2)	(3)	(4)
GI	0.672			
KM	0.243	0.680		
GI × GKM	0.398	0.111	0.700	
ST	0.200	0.452	0.490	0.646

Source: This study.

Assessment of The Structural Model

The overall fit of the structural model was acceptable because all of the measures of fit reached an acceptable level ($\chi 2$ =39.449, df = 24, α = 0.001; GFI = 0.975; AGFI = 0954; CFI = 0.986; NFI = 0.964; RMSEA = 0.045; SRMR =0.025). The Skewness and Kurtosis indexes of all the items were lower than 2, and the Mardia's (1970) coefficient was lower than p (p+2), where p is the number of items of individual construct, indicating that there is multivariate normality (Bollen, 1989; Bollen and Long, 1993). The use of Mardia's coefficient to test multivariate normality follows previous studies (e.g., Tsigilis et al., 2004; Menor and Roth, 2008). In the SEM analysis, the relationships among the independent and dependent variables were assessed simultaneously via a covariance analysis. A maximum likelihood (ML) estimation was used to estimate the model parameters, with the covariance matrix as data input. The ML estimation method has been described as being well suited to theory testing and development (Anderson and Gerbing, 1988; Jöreskog and Sorbom, 1993). Figure 2 shows the structural model with the coefficients for each path (hypothesized relationship), with solid and dashed lines indicating supported and unsupported relationships, respectively. The green innovation (H1: γ = 0.410, t = 0.7612, p<0.001), green knowledge management (H2: γ = 0.700, t = 0.8561, p<0.001) had significantly positive effects on sustainable transition of supply chain resilience. Thus, all of our hypotheses were supported.

DISCUSSION

This research provides a new model to explain green innovation moderated by green knowledge management to influence sustainable transition within supply chains. This research examines and analyze the data by the Structural Equation Modeling technique (Anderson, J.C et al., 1988) to complex relationships between variable, and the results would predicted be good. Green knowledge management is a moderator factor (Baron, R. M. et al., 1986) in this research, plays a pivot role to influence the sustainable transition with green innovation. In the past, much research focus on green innovation effects on sustainable transition, but less research discusses with how enhanced green innovation to sustainable transition, the concept is a contribution in this study.

REFERENCES

Ali, Q., Parveen, S., Yaacob, H., Rani, A. N., & Zaini, Z. (2022). Environmental beliefs and the adoption of circular economy among bank managers: Do gender, age and knowledge act as the moderators? *Journal of Cleaner Production*, *361*, 132276. https://doi.org/10.1016/j.jclepro.2022.132276

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Baron, R. M. and Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Bollen, K. A. (1989). *Structural equations with latent variables*. John Wiley & Sons. https://doi.org/10.1002/9781118619179

Bollen, K. A., & Long, J. S. (Eds.). (1993). *Testing Structural Equation Models*,154, *Sage Publications*, Inc.

Di Vaio, A., Palladino, R., Pezzi, A., & Kalisz, D. E. (2021). The role of digital innovation in knowledge management systems: A systematic literature review. *Journal of Business Research*, *123*, 220-231. https://doi.org/10.1016/j.jbusres.2020.09.042

Elzen, B., Geels, F., & Green, K. (2004). *System Innovation and the Transition to Sustainable: Theory, Evidence and Policy*. Edward Elgar Publishing.

Granco, G., Heier Stamm, J. L., Bergtold, J. S., Daniels, M. D., Sanderson, M. R., Sheshukov, A. Y., Mather, M. E., Caldas, M. M., Ramsey, S. M., Lehrter Ii, R. J., Haukos, D. A., Gao, J., Chatterjee, S., Nifong, J. C., & Aistrup, J. A. (2019). Evaluating environmental change and behavioral decision-making for sustainable policy using an agent-based model: A case study for the Smoky Hill River Watershed, Kansas. *Science of The Total Environment*, *695*, 133769. https://doi.org/10.1016/j.scitotenv.2019.133769

Grin, J., Rotmans, J., & Schot, J. (2010). *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. Routledge.

Cheng, J. H. & Sheu, J. B. (2016). Inter-organizational relationships and strategy quality in green supply chains - Moderated by opportunistic behavior and dysfunctional conflict. *Industrial Marketing Management*, *41*(4), 563-572. https://doi.org/10.1016/j.indmarman.2012.04.003

Joreskog, K. G., & Sorbom, D. (1993). LISREL 8: Structural equation modeling with the SIMPLIS command language. *Chicago: Scientific Software International*.

Kroes, J. R. & Ghosh, S. (2010). Outsourcing congruence with competitive priorities: impact on supply chain and firm performance. *Journal of Operations Management*, *28*(2), 124-143. https://doi.org/10.1016/j.jom.2009.09.004

Mardia, K. V. (1970). Measures of multivariate skewness and kurtosis with applications. *Biometrika*, *57*(3), 519–530. https://doi.org/10.1093/biomet/57.3.519

Shehzad, M. U., Zhang,J., Latif, K. F., Jamil, K., & Waseel, A. H. (2023). Do green entrepreneurial orientation and green knowledge management matter in the pursuit of ambidextrous green innovation: A moderated mediation model. *Journal of Cleaner Production*, *388*, 135971. https://doi.org/10.1016/j.jclepro.2023.135971

Jahangiri, S., & Shokouhyar, S. (2024). An integrated FBWM-FCM-DEMATEL model to assess and manage the sustainability in the supply chain: A three-stage model based on the consumers' point of view. *Applied Soft Computing*, *157*, 111281. https://doi.org/10.1016/j.asoc.2024.111281

Takalo, S. K., Tooranloo, H. S. & Parizi, Z. S.(2021). Green innovation: A systematic literature review. *Journal of Cleaner Production*, *279*, 122474. https://doi.org/10.1016/j.jclepro.2020.122474

Le, T. T., Nhu, Q. P. V., Bao, T. B. N., Thao, L. V. N., & Pereira, V. (2024). Digitalisation driving sustainable corporate performance: The mediation of green innovation and green supply chain management. *Journal of Cleaner Production*, *446*, 141290. https://doi.org/10.1016/j.jclepro.2024.141290

Wang, C., & Hu, Q. (2020). Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance. *Technovation*, *94*, 102010. https://doi.org/10.1016/j.technovation.2017.12.002