

A Scientometrics Review on Research of Knowledge Sharing in Virtual Communities

(Full Paper)

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ABSTRACT

The number of literature on knowledge sharing in virtual communities has gained rapid growth during last decade; however, there have been few attempts to map the global research in this domain. In this study, the CiteSpace software package was used to conduct a series of content analyses to identify the state of the field and trends in knowledge sharing in virtual communities, including the distribution of core authors and institutions; high-frequency categories and keywords; highly cited papers and hot topics of research; and trends pertain to co-author analysis, co-word analysis, co-citation analysis, and particularly cluster analysis. We present all research focuses in a scientometric way and arrive at the following findings. First, the most significant developments and progress in knowledge sharing in virtual communities have occurred primarily in China, Taiwan, USA, Malaysia. Second, the existing studies in the field of knowledge sharing in virtual communities focus primarily on Business & Economics, Engineering and Computer Science. Third, five hot knowledge sharing in virtual communities topics were also disclosed, they are: knowledge sharing, virtual communities, trust, behavior, management and network.

Keywords: Knowledge sharing, virtual community, Web of Science, CiteSpace

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INTRODUCTION

The emergence of the Internet enables users to interact and share information through virtual space or cyberspace. The interaction, openness and sharing of the Internet have enabled knowledge and information to be transmitted to all corners of the world, and the geographical boundaries of traditional communities have been weakened. Users from all walks of life join virtual communities in order to share their knowledge relevant to common interests and topics (Tamjidyamcholo, 2014). Virtual community, also known as an online community, refers to an online social network in which individuals have common interests, goals, and behaviors share knowledge and participate in social interaction (Chiu, 2007). As a new type of interaction mode, virtual community can break through the limitations of time and space, improving people's interaction efficiency and becoming a new platform for people to exchange information and share knowledge. Many organizations view virtual communities as the key to knowledge management. They are increasingly focusing on the operation and development of virtual communities to achieve their operational goals. The key to the prosperity and development of virtual communities is knowledge sharing among community members. Therefore, it is of great significance to study the influencing factors, sharing process and sharing mechanism of virtual community knowledge sharing for community managers to develop targeted incentives and effective community management.

Because of the importance of knowledge sharing in virtual communities, scholars are increasingly concerned about related topics. A large number of high quality studies have emerged in recent years. A number of literature reviews on knowledge sharing in virtual communities have been completed. Charband and Navimipour (2016) offer a comprehensive, detailed, and systematic study of the state-of-the-art knowledge sharing mechanisms in an online environment. Assegaff and Kurniabudi (2017) apply literature review study as main approach to identify factors related with people barriers when contributing their knowledge through virtual communities. Li *et al.* (2018) systematically discussed the theories that most studies took, summarize existing empirical study of knowledge sharing in virtual communities, and identified four mostly used representative theories. Unlike previous reviews of knowledge sharing in virtual communities, we conducted a scientometric review and obtained a snapshot of this fast-growing field between January 1999 and December 2017. Scientometric review is an important approach to make comprehensive evaluation of the development of regarding research area (Kim & Chen, 2015). Our findings could assist researchers in better understanding the dynamics of knowledge sharing in virtual communities and in identifying the frontier of knowledge sharing in virtual communities research.

The purpose of this study is as follows: First, we try to identify the most productive contributors, including individual and institutional researchers, based on co-author analyses at the country, institution and author levels. Second, through co-word analyses at the keyword, term and category levels, we strive to reveal the major categories and primary research topics in the field of knowledge sharing in virtual communities. Third, we seek to illuminate the distribution of core articles, authors and journals related to knowledge sharing in virtual communities by mapping co-citation networks at the document. Finally, the vital goal of this paper is to detect the hot research topics and trends in the field of knowledge sharing in virtual communities.

METHODOLOGY

Data Collection

Database

Web of science (WOS) is an ideal choice for obtaining data sources in bibliometric research, bringing researchers representativeness and accuracy. It covers the world's most influential journals and covers multiple disciplines. In addition, it provides researchers with web-based bibliographic and citation information access. Most of the main papers on virtual community knowledge sharing can be retrieved in WOS, and relevant publications can be easily extracted through appropriate search strategies. Therefore, this study used the WOS core collection database as the selection data set.

Defining search keywords

The research goal of this review is to explore the knowledge landscape in the knowledge sharing field. A priority is obvious that each research field has various types of relevant keywords. Traditionally, the process of defining the keywords was relied on the summarizing of previous papers. We use web of science as data source and use "Title= (virtual knowledge sharing) OR Title= (online AND knowledge sharing), Database= (SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC), Languages= (ENGLISH), Timespan= 1999-2017" as search factors.

Refinement of data

After obtaining 271 bibliographic records, we further refined the data to two types: articles and reviews. This refinement brought us a valid final literature set of 262 publications for further analysis. Most publications are articles.

ANALYSIS OF PUBLICATION OUTPUT

Figure 1 shows the snapshot of annual publication output. Papers in this field started primarily at 1999 and the distribution of bibliographic records was divided into two main phases. The first stage, named emergence, dates from 1999 to 2006. The annual number of papers published was less than 10 and these achievements aimed at importing the basic theory and laid a foundation for the later researches. The second stage are defined as an expansion phase, in which the production achieved an uppermost point in 2007. Although there is a decline during 2010 and 2013, a rapid growth occurred between year 2014 and 2017 again. As presented in Figure 1, the number of publications pertain to knowledge sharing in virtual communities showed an overall increase trend, indicating that researchers have been concerning this topic with a rising heat and have achieved a wealthy of publications. In 2017, the actual number of publications shows a little decline trend, but the published quantity index still shows an upward trend. All in all, the research stage in terms of knowledge sharing in virtual communities have not gone into the mature phase and more publications will appear in the future.

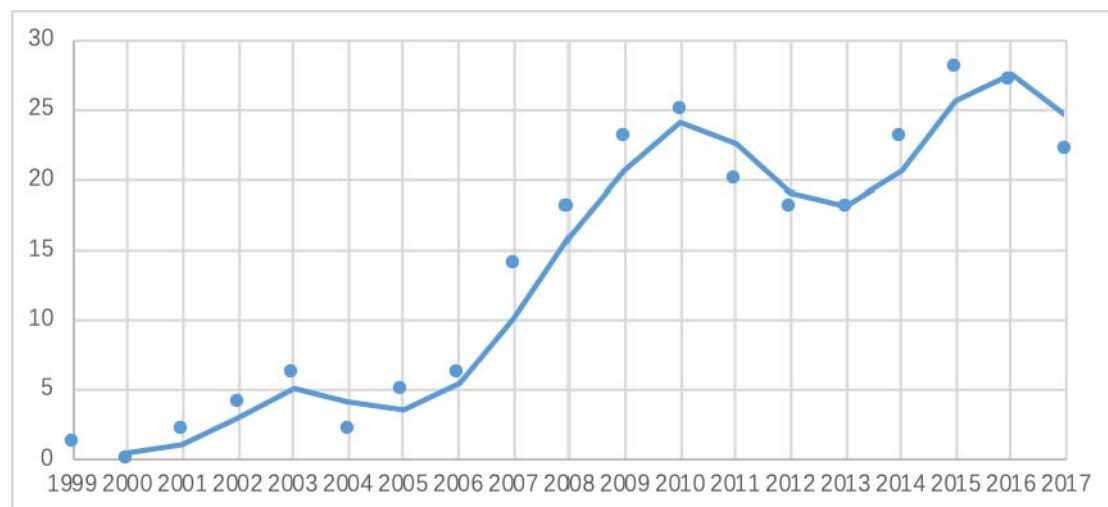


Figure 1: Trends in the number of scholarly publications concerning knowledge sharing in virtual communities research from 1999 to 2017.

CO-AUTHORSHIP ANALYSIS

Co-authorship Network

Co-authorship networks are an important class of social networks and have been analyzed extensively, both at network level and individual node level, to explore different statistical characteristics (Newman, 2001) and behavioral patterns of scientific collaborations (Liu *et al.* 2005). Through the co-authorship analysis, we can obtain the productivity of authors, recognize the research teams and their core builders. Figure 2 shows the outputs and author cooperation network knowledge map in research of knowledge sharing in virtual communities. All the primary authors of this research field are presented in the map, in which 22 nodes and 10 links exist. Every node represents an author; the node's size indicates the productivity of each author and the links reflect the collaboration relationships among authors.

The statistical analysis demonstrated that the 262 publications on research of knowledge sharing in virtual communities were drafted by more than 22 authors. The top-5 most scholarly productive researchers are presented in table 1. It is obvious that Pee, L.G., a professor who belongs to Nanyang Technology University, is the most productive author in the field of knowledge

sharing in virtual communities, followed by HARA N, LI JY, CHANG KE and HOU HT. As seen in Table 1, the first publication years of these productive authors are distributed between 2015 and 2017. Pee, L.G. started his research in 2015 and he is the latest one to start in the top-5 authors, however, he is the most efficient author with 4 papers in 3 years. Hara Noriko, Li Jinyang, Chang Kuo-En and Hou Huei-Tse all pressed 2 papers and Hara Noriko is the earliest one.

Regarding the collaborative relationships, as shown in Figure 2, we can draw the conclusion that there are some research communities and most community has one main highly productive author, to whom many other authors connect. For example, professor Pee, L.G. occupies the core position of a community and has direct close connections with three other authors, including Lee, J. and Min, Jinyong. Furthermore, the number of nodes is 2 times the number of links, indicating that cooperation strength between researchers is weak.



Figure 2: co-authorship network, with 22 nodes and 10 links

The co-authorship analysis help recognize the authors with high productivity based on the co-occurrence frequency criterion. A prior it is that the level of output can't represent the influence and contribution. In the later co-citation part, we will explore the relationship between the productivity and influence by comparing the conclusions in these two parts.

Table 1: The top-5 most productive authors and their publication frequencies and institutions

Ranking	Frequency	Year	Author
1	4	2015	Pee, L.G.
2	2	2007	Hara, Noriko
3	2	2015	Li Jinyang
4	2	2009	Chang, Kuo-En
5	2	2009	Hou, Huei-Tse

RESEARCH POWER NETWORK

Collaboration between different countries and institutions facilitates the sharing of useful information and provides researchers with more diverse research materials. To explore the distribution of publications on knowledge sharing in virtual communities and the collaboration relationships, a cooperative network was generated in terms of institutions and countries.

A network on behalf of the collaborating countries and institutions between 1999 and 2017 has been provided in Figure 3, in which every node represents a country or an institution and the 13 nodes and 13 links indicate a weak cooperation state. It is obvious that the major contributions concerning the total publication output are mainly derived from China, Taiwan, USA, Malaysia and England in Table 2. In terms of the frequency distribution, 262 papers are distributed among 13 countries and 20 institutions. The top-10 countries totally published 203 papers, accounting for 80%. It is clear that the largest node in the figure is China, which is the largest contributor publishing 65 papers. Aisa is the most productive region publishing 138 papers, including 65 from China, 45 from Taiwan, 12 from Malaysia, 9 from South Korea and 7 from Singapore. According to the

color of the nodes and links, we can see that the time these mainly productive countries started digging into the research of knowledge sharing in virtual communities was earlier, indicating a very obvious time accumulation characteristic of academic research.

Collaboration networks exist in different countries and institutions, interestingly, although some research bodies come from the same region, there is no direct relationships among them. For example, the Chinese mainland and Malaysia are both prominent nodes, ranking first and fourth, and they are free of cooperation with each other.

Figure 3 and Table 2 also presents the cooperation networks among institutions in the domain of knowledge sharing in virtual communities. From the analysis of productive countries and the regional information of these more productive institutions, we can draw the conclusion that there exists a high level of consistency between the high-yield countries and institutions. For example, the most productive institution - National Central University is from Chinese mainland and the third productive institution is from Taiwan. Other similar relationships can be recognized in the same way. But there also exist exceptions. Although researchers coming from Malaysia, England and South Korea published 32 papers in this field, ranking fourth, fifth and sixth in the top-10 countries respectively. None of the top-8 institutions come from these three countries, in which the sense of cooperation among researchers wasn't strong over the past two decades.

Table 2: The top-10 most productive countries, institutions and their publication frequencies.

Ranking	Frequency	Country	Frequency	Institution
1	65	CHINA	7	Natl Cent Univ
2	45	TAIWAN	6	Nanyang Technol Univ
3	42	USA	4	Natl Taiwan Univ Sci & Technol
4	12	MALAYSIA	2	Indiana Univ
5	11	ENGLAND	2	Donghua Univ
6	9	SOUTH KOREA	2	Virginia Tech
7	7	SINGAPORE	2	Natl Cheng Kung Univ
8	6	ITALY	2	Univ Indonesia
9	4	GERMANY	2	Coventry Univ
10	2	AUSTRALIA	2	Univ Washington



Figure 3: Research power network, with 13 nodes and 13 links

CO-WORD ANALYSIS

To explore what areas have been most concerned in the field of knowledge sharing in virtual communities during the time periods covered by this study, we use the co-word analysis to estimate the research focuses. Furthermore, we also detect the bursts to clear the frontiers.

Co-occurring Categories Analysis

Figure 4 provides a network of co-occurring subject categories in research of knowledge sharing in virtual communities, including 32 nodes and 69 links. Statistical analysis showed that the Computer Science (130) and Business & Economics (80) were the most productive areas of all, followed by Information System (72), Management (64), Information Science & Library Science (47), Engineering (43) in Table 3. Furthermore, considering the initial years of the top-10 productive categories, we assigned the publications into four stages. The numbers in last stage are less than the third stage because the last stage 2014-2017 only covers 3/4 of the next four years. Considering this reality and observing the trend, we can get the obvious conclusion that publications of each category in the four stages shows an upward trend in terms of the increase in number. The growth rate in the third stage, years between 2009 and 2013, is fastest compared to other stages. Studies focusing on Business & Economics, Engineering and Computer Science have significantly increased in the total publications output. Similarly, categories of Management and Business have gradually increased in number of studies. In the present time, Business & Economics is the fastest developing field in the research of knowledge sharing in virtual communities.

As shown in figure 4, not all the bigger size nodes have red-purple rings, indicating that the nodes reflecting high level of production aren't consistent with those nodes reflecting high centrality. In the knowledge map, high centrality nodes are recognized in the categories of Engineering (0.43), Psychology (0.38), Computer Science (0.32), Electrical & Electronic (0.20), Management (0.16) and Business (0.16). All these categories have made a significant motive force on the development of knowledge sharing in virtual communities.

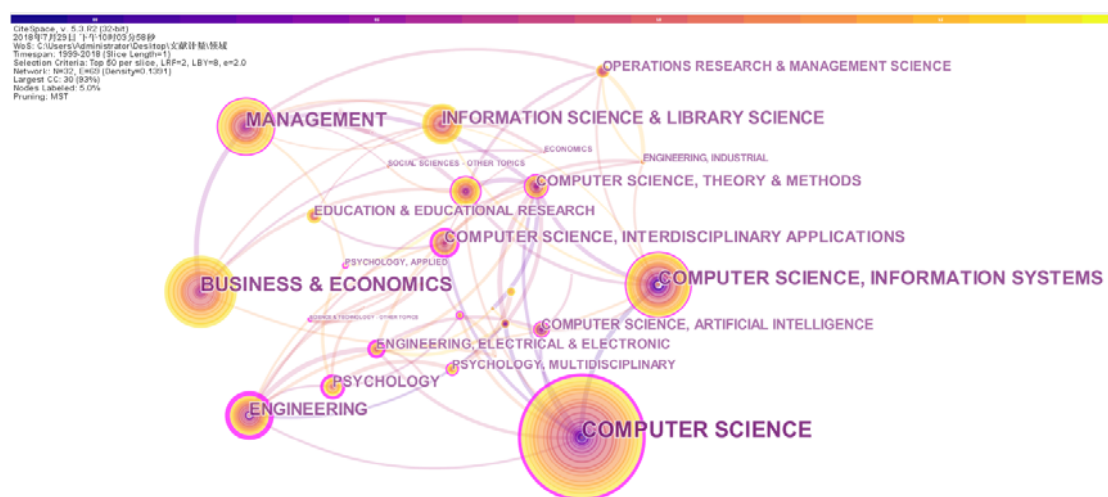


Figure 4: Co-occurring categories (WOS categories) network, with 32 nodes and 69 links

Table 3: The top-10 research categories and their co-occurrence frequency

Ranking	Frequency	Year	Category	1999-2003	2004-2008	2009-2013	2014-2017
1	130	2001	COMPUTER SCIENCE	11	29	54	36
2	80	2005	BUSINESS & ECONOMICS	0	13	33	34
3	72	2001	INFORMATION SYSTEMS	8	15	26	23
4	64	2005	MANAGEMENT	0	12	24	28
5	47	2007	INFORMATION SCIENCE & LIBRARY SCIENCE	0	4	22	21
6	43	2002	ENGINEERING	2	7	22	12
7	33	2005	BUSINESS	0	6	11	16
8	31	2003	INTERDISCIPLINARY APPLICATIONS	3	8	15	5
9	26	2003	THEORY & METHODS	3	6	9	8

CO-OCCURRING KEYWORDS ANALYSIS

The key word of the article is to concentrate the core content. Through co-occurrence analysis, high frequency keywords are obtained, summing up research priorities in the knowledge sharing field and detect the bursts to make a brief overview of the research frontier. On the basis of merging similar words or different words with same meaning (for example, the words “virtual community”, “online community”, “communities”, “virtual team” and “virtual enterprise” were mapped to “virtual community” and “knowledge sharing”, “knowledge-sharing”, “online knowledge sharing” and “knowledge management” were mapped to “knowledge sharing”), a final keyword co-occurrence knowledge map was established in Figure 5 based on the choose of keyword as the node type and the merger of some related keywords, in which there were 96 nodes and 179 links.

Since we used “knowledge sharing” and “virtual communities” as the search keywords, it is not surprising that they have the highest frequencies, 142 and 114 respectively. The keywords “trust”(56), “behavior”(45) and “self-efficacy”(16) represent the factors that influence knowledge sharing; “management”(34), “network”(31), “organization”(18) explain represent the application areas of knowledge sharing.

As shown in Figure 5, focuses of knowledge sharing in virtual communities and correlations among hot topics can be drawn on the basis of the size of nodes and the links between keywords analysis. For instance, researches regarding knowledge sharing in virtual communities are correlated with trust, internet, behavior, management and collaboration. Therefore, we can see that researches on the core focus user innovation contains three types of sub hot topics: effects of knowledge sharing in virtual communities, knowledge sharing management and ways for motivate knowledge sharing.

Table 4: The top-10 keywords and their frequency

Ranking	Frequency	Year	Category
1	142	2001	Knowledge Sharing
2	114	2006	Virtual Community
3	56	2005	Trust
4	45	2005	Behavior
5	34	2007	Management
6	31	2008	Network
7	30	2010	Perspective
8	28	2007	Model
9	18	2010	Organization
10	16	2013	Self-efficacy

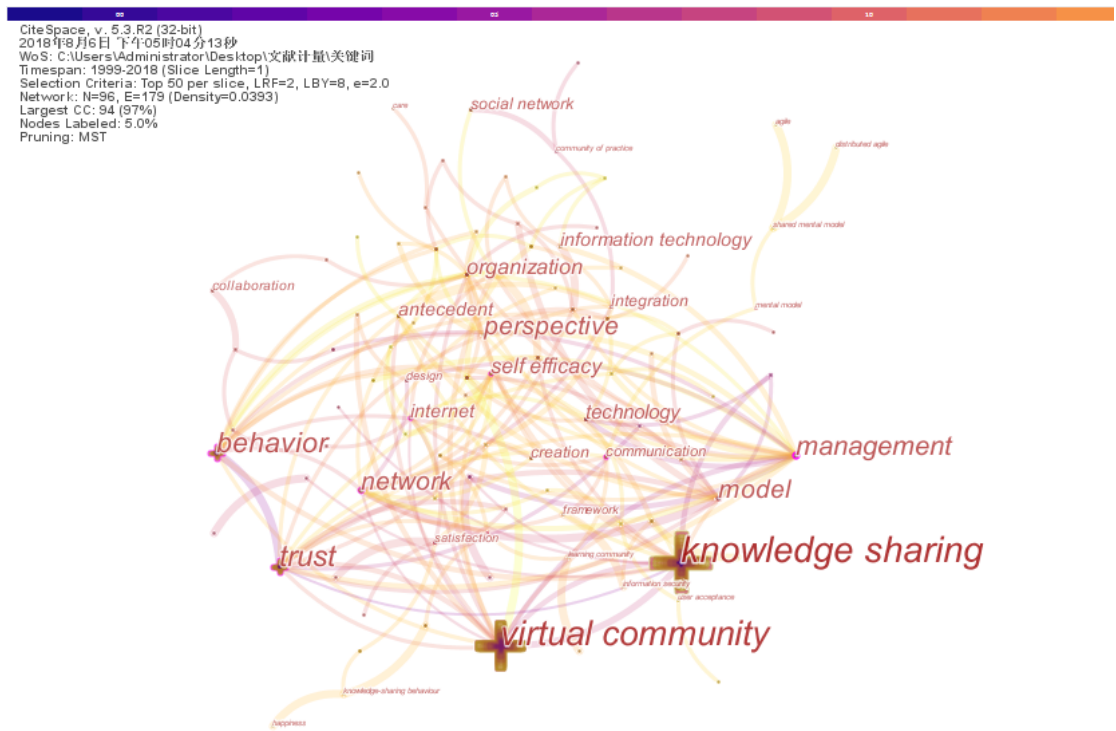


Figure 5: co-occurring keywords network, with 96 nodes and 179 links

CO-CITATION NETWORKS

Document Co-citation Network

Document co-citation analysis is a statistical method. It can be used not only reveal the quantity and authority of references cited by published papers, but also predict future research directions (Song & Dong, 2016). And the clusters generated during this process are important analytical units for cluster analysis.

Based on an analysis of the comprehensive collection and coordination of the 818 academic documents cited in the 262 records retrieved from the WOS core collection, the top 10 cited documents are summarized in table 4, from No.1 to No.10. Table 4 provides detailed descriptions of these documents in terms of their citation frequencies, publication years, document titles and corresponding clusters.

Table 5: The top 10 cited documents

Ranking	Frequency	Author	Year	Title	Cluster ID
1	41	HSU MH	2007	Knowledge sharing behavior in virtual communities: The relationship between trust, self-efficacy, and outcome expectations	3
2	36	Chiu CM	2007	Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories	0
3	35	Wasko ML	2005	Why should I share? Examining social capital and knowledge contribution in electronic networks of practice	0
4	30	Kankanhall A	2005	Contributing knowledge to electronic knowledge repositories: An empirical investigation	0
5	28	Bock GW	2005	Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social psychological forces, and organizational climate	0
6	22	Lin MJJ	2009	Fostering the determinants of knowledge sharing in professional	1

virtual communities					
7	14	Wang S	2010	Knowledge sharing: A review and directions for future research	2
8	14	Chang HH	2011	Social capital and individual motivations on knowledge sharing: Participant involvement as a moderator	1
9	13	Chen CJ	2010	To give or to receive? Factors influencing members' knowledge sharing and community promotion in professional virtual communities	1
10	12	HSU CL	2008	Acceptance of blog usage: The roles of technology acceptance, social influence and knowledge sharing motivation	1

A summary of the top 10 documents is presented in Table 4. As described in top 4 documents, a framework for knowledge sharing in virtual communities was formed. This framework specifies why people will share knowledge in virtual communities and what influence the willingness of knowledge sharing. (Hsu, 2007; Chiu, 2007; Wasko, 2005; Kankanhall, 2005). Based on the framework, user innovation studies from different perspectives emerged. Hsu (2007) proposed a model that includes knowledge sharing self-efficacy and outcome expectations for personal influences, and multidimensional trusts for environmental influences. The research showed that self-efficacy has both direct and indirect effects on knowledge sharing behavior, personal outcome expectations have significant influence on knowledge sharing behavior. Chiu (2007) investigated the motivations behind people's knowledge sharing in virtual communities. The study held that the facets of social capital-social interaction ties, trust, norm of reciprocity, identification, shared vision and shared language will influence individuals' knowledge sharing in virtual communities. Wasko (2005) found that people contribute their knowledge when they perceive that it enhances their professional reputations, when they have the experience to share, and when they are structurally embedded in the network. Kankanhall (2005) employed social exchange theory to identify cost and benefit factors affecting electronic knowledge repositories usage, and social capital theory to account for the moderating influence of contextual factors. The results reveal that knowledge self-efficacy and enjoyment in helping others significantly impact electronic knowledge repositories usage by knowledge contributors.

ANALYSIS OF CO-CITATION CLUSTERS

Based on the co-citation analysis of the literature, we can identify highly cited documents in each cluster that represent the key focus of each field, and based on these findings, combined with expert analysis, we can also explain the relationship between clusters and clusters. The color of each cluster indicates that cooler colors are closer to the year of 1999 whereas hotter ones represent close years to 2017.

Figure 6 visualizes the comprehensive research landscape in knowledge sharing in virtual communities. Each node on the time lines portrays a cited article by knowledge sharing in virtual communities. References with citation bursts are depicted with rings in yellow. Landmark articles are labeled. The cluster numbers are also labeled in ascending order, based on the number of references included in each cluster. That is, the more references the clusters have, the higher rankings they are given. It is evident that Cluster #0 has a high concentration of nodes in the light of citation bursts, which indicates that this is the most recently formed cluster. In addition to Cluster #0, Cluster #1 and #3 appear to have recent publications with citation bursts. As shown in figure 4, there are only 8 recent clusters emerging in the domain. We assume that this is because this domain is relatively new, still emerging, and developing.

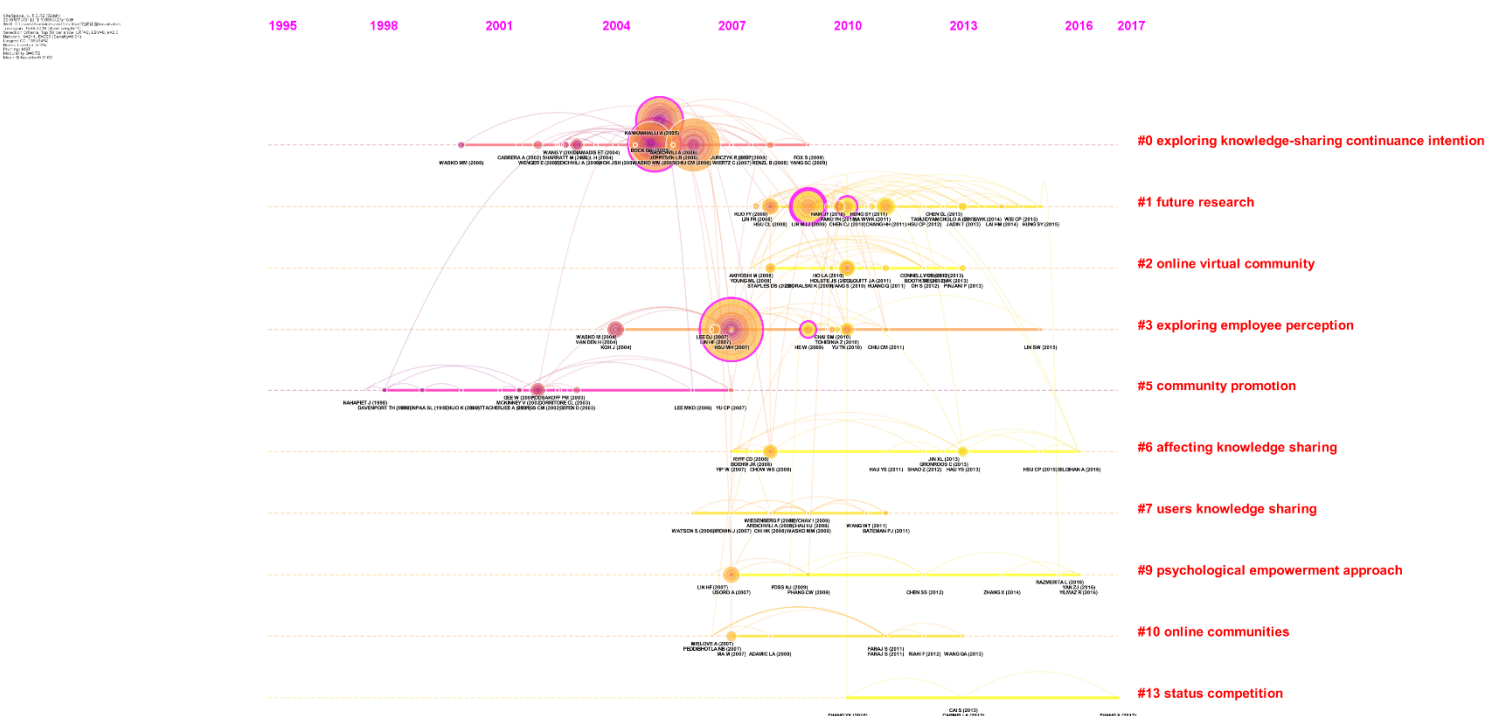


Figure 6: Timeline visualization of knowledge sharing in virtual communities

CONCLUSION

Knowledge sharing in virtual communities has been widely recognized and are attracting increasing attention. Researchers has strived to ensure the success of virtual community knowledge sharing. Based on 271 papers published from 1999 to 2017, this study collects papers from the WOS core collection database and provides a new scientific visualization method through knowledge domain mapping to explore the status and direction of knowledge sharing in virtual communities. The increasing published quantity index over time that pertain to knowledge sharing in virtual communities indicates that increasing attention is being directed toward user knowledge sharing research.

To identifying the status and trends of the domain in the virtual community knowledge sharing, a series of content analyses in this research examines the tendencies exhibited by publications from around the world, including the distribution of core authors and institutions, highly cited papers and high-frequency classifications, and keywords, popular research topics and trends. To visualize these trends, we applied co-author analysis, co-word analysis, co-citation analysis, and especially cluster analysis.

Regarding the contributions and influences of the lead authors identified in the co-authorship analyses, Pee, L.G. is the most productive author in the field. Considerable attention should be paid to Hara Noriko, Li Jinyang, Chang Kuo-En and Hou Huei-Tse.

In the distribution of publications on knowledge sharing in virtual communities, such publications are mainly derived from China, Taiwan, USA, Malaysia. National Central University, Nanyang Technology University, Natl Taiwan University Science & Technology are the most productive institutions in knowledge sharing in virtual communities.

Regarding the subject categories addressed in research on knowledge sharing in virtual communities, Business & Economics, Engineering and Computer Science may represent the major intellectual turning points linking studies from different phases and may have had significant influence on the development of knowledge sharing in virtual communities.

By analyzing the co-occurring keywords, high-frequency keywords are identified, and the results indicate that the various focuses of knowledge sharing in virtual communities in terms of research contents, Application areas and research methods are constantly evolving from 1999 to 2017.

The results of document co-citation analysis show that the most highly cited article, published by Pee, L.G. (2015), provides an overview of what the international research community now understands about knowledge sharing in virtual communities. Moreover, 4 typical clusters were identified based on the keywords and title terms associated with the analyzed documents, and the focuses of these clusters can be divided into 4 topics: exploring knowledge-sharing continuance intention, future research, online virtual community, exploring employee perception.

The information provided in this article is valuable to researchers and practitioners in the virtual community knowledge sharing area. The analysis provides insights from key academics and research institutions, focusing on core topics, and state of the research field. In addition, for practitioners, the results of this research report will enable practitioners to benefit more from the core research or core research results, and help them to follow appropriate procedures and select the appropriate advisory body for their application.

Therefore, the bibliographic records analyzed in this paper represent a sufficiently large, high-quality research system that accurately reflects the global picture of knowledge sharing in virtual communities, even though these records do not contain every publication on knowledge sharing in virtual communities.

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