

Research on Knowledge Sharing in Virtual Academic Communities Based on Social Network Analysis (Postprint)

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Abstract

[Purpose / Significance] The emergence of virtual academic communities provides researchers with new channels for collaborative exchange, participation in peer review, and sharing of research achievements. Confronted with the decentralized, fragmented, and time-sensitive nature of massive academic information in the Science 2.0 environment, promoting researchers' utilization of virtual academic communities for rapid and efficient knowledge sharing has become a significant issue in the big data era. [Method / Process] Taking ScienceNet as an example, this study employs social network analysis to identify opinion leaders within virtual academic communities. By calculating centrality and influence coefficient metrics, it elucidates the crucial role of opinion leaders in knowledge sharing, subsequently designs a member relationship model for virtual academic communities, and further analyzes the primary factors influencing knowledge sharing. [Results / Conclusion] The study constructs a knowledge sharing pathway for virtual academic communities, achieves coordinated online and offline development, enhances knowledge coupling and reusability, and thereby promotes scientific research innovation.

Full Text

Research on Knowledge Sharing in Virtual Academic Communities Based on Social Network Analysis

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Abstract

[Purpose/significance] The rise of virtual academic communities provides researchers with a new channel for collaborative exchange, peer review partic-

ipation, and sharing of research findings. Faced with the dispersion, fragmentation, and timeliness of massive academic information in the Science 2.0 environment, promoting rapid and efficient knowledge sharing among researchers through virtual academic communities has become a critical issue in the big data era. [Method/process] Taking ScienceNet as an example, this study employs social network analysis to identify opinion leaders in virtual academic communities. By calculating centrality and influence coefficients, it highlights the important role of opinion leaders in knowledge sharing, designs a member relationship model for virtual academic communities, and further analyzes the main factors affecting knowledge sharing. [Result/conclusion] The study constructs a knowledge sharing pathway for virtual academic communities, achieves collaborative online and offline development, improves knowledge coupling and reusability, and thereby promotes scientific innovation.

Keywords: Virtual academic community, Social network analysis, Knowledge sharing

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Introduction

According to the 40th CNNIC statistical report, as of June 2017, China's internet user population had reached 751 million, with an internet penetration rate of 54.3%. The Web 2.0 era places greater emphasis on the interactivity of online user behavior. As a platform for network information derivation and dissemination, the internet has evolved into refined, vertical social networking platforms such as Weibo and WeChat, which can also be called virtual communities. Information flow and knowledge sharing form the foundation for the existence and development of virtual communities. Against the backdrop of digitalization and the "Internet Plus" initiative, communication methods among researchers have also transformed, giving rise to virtual academic communities. Virtual academic communities are a type of virtual community whose core is a cyberspace for knowledge sharing supported by information technology [1]. Currently, internationally renowned virtual academic communities such as ResearchGate have over 13 million registered members, while Academia.edu has over 53 million registered members. Domestically, the more mature virtual academic community XiaoMuChong has also exceeded 6 million registered users [2].

The primary functions of virtual academic communities are to strengthen collaborative exchange among researchers, promote scientific innovation, and simultaneously share research achievements to achieve mutual learning. Domestic research on knowledge sharing in virtual communities is relatively abundant, with 436 relevant papers published on CNKI from 2004 to 2018. Representative

studies in the past three years include: Huang Jialiang et al. [3] examining virtual community knowledge sharing models and system architecture in the big data context; Huang Wei et al. [4] investigating factors influencing user knowledge sharing behavior in virtual communities; Wang Peng et al. [5] introducing lifecycle theory into virtual community knowledge sharing and conducting further game analysis; Yang Chen et al. [6] studying knowledge sharing patterns in relationship-based virtual communities; Zhang Min et al. [7] applying the S-O-R paradigm to analyze factors influencing knowledge sharing in virtual communities; and Geng Ruili et al. [8] providing a comprehensive review of characteristics and content of knowledge sharing among social network users. In contrast, research on virtual academic communities is scarce, with only 20 relevant papers published on CNKI from 2010 to 2017. Representative papers include: Wang Dong et al. [9-10] studying the framework of knowledge sharing implementation mechanisms in virtual academic communities; and Zhang Min et al. [11] conducting game analysis of knowledge sharing subjects in virtual academic communities from a trust perspective.

A comprehensive review of recent scholarly research on knowledge sharing in virtual communities and virtual academic communities reveals two main focuses: first, review studies on the basic concepts and content of knowledge sharing in virtual communities; and second, research on influencing factors and subject game analysis related to knowledge sharing in virtual communities. These studies have laid a solid foundation for this research. At the same time, they reveal that research materials on knowledge sharing in virtual academic communities are very limited. Although virtual academic communities are a type of virtual community, they have distinct differences. Identifying the main factors affecting knowledge flow and knowledge sharing based on these unique characteristics, and proposing effective pathways to promote the sustainable development of virtual academic communities, is particularly important. This paper employs social network analysis to identify central figures in virtual academic communities, measures emotional density through both online and offline dimensions, designs effective knowledge sharing pathways, enables sufficient exchange among members across different times and spaces, allows for deep knowledge sharing and reuse, and provides an innovative collaborative platform for researchers.

1 Feasibility Analysis of Social Network Analysis Methods in Virtual Academic Community Knowledge Sharing

Social Network Analysis (SNA) is an interdisciplinary quantitative method that comprehensively applies mathematics, graph theory, computer science, and other disciplines to measure, evaluate, and visualize individual relationship patterns in networks [12]. SNA consists of nodes and connections, where nodes represent actors in events and connections represent relational ties between them. This is a method for studying dynamic relationships among multiple entities, which together constitute a relational network diagram. Depending on different research purposes, the objects represented by actors can vary—nodes can

be organizations, individuals, or technologies, while connections can be transactional relationships between organizations, emotional relationships between individuals, or citation relationships between technologies. These interwoven and complex relationships form network structures, which enable each actor to occupy a certain position with specific characteristics within the network. Network structure and position can provide rich information about individuals and their relationships, facilitating reasonable analysis and prediction of actor behaviors.

The advantage of SNA lies in its ability to analyze networks with multiple nodes and subjects, which aligns precisely with the multi-subject participation characteristic of virtual academic communities. Additionally, SNA can grasp the overall patterns and characteristics of data for preliminary descriptive analysis. Building upon this foundation, it can also uncover deep-level internal correlations through hypothesis testing, conduct data correction and adjustment, and establish a solid data analysis foundation for further research.

Therefore, employing this scientometric method, which excels in studying network relationships, to investigate knowledge sharing in virtual academic communities is highly appropriate. Knowledge exchange and sharing are the most important activities in virtual academic communities, and these activities and behaviors are embedded within social relationship networks. This paper will use SNA to examine the social relationship networks in virtual academic communities, further explore network structural characteristics, and investigate knowledge sharing behavior patterns.

Network density can characterize the degree of interaction among members in virtual academic communities, typically ranging from 0 to 1. If network nodes exist in isolation, the value is set to 0; if interactions are frequent, the value is set to 1. Higher network density indicates more sufficient knowledge sharing among members, while lower density hinders effective communication and increases sharing costs.

Through centrality calculations, central figures in network communities can be identified. SNA places great emphasis on studying central figures because it can describe differences in hierarchy, status, and social prestige among actors, reflecting social structural characteristics. An actor with high centrality has many direct connections with other members in the academic community and is highly influential; their knowledge sharing resources and willingness significantly affect knowledge sharing behaviors. Simultaneously, by analyzing centrality and influence coefficients, the role of each member in knowledge sharing within the virtual community can be determined, further exploring member composition and the main factors influencing knowledge sharing.

Using SNA to examine social relationship networks, knowledge flow, knowledge sharing behaviors, and main influencing factors among users in virtual academic communities represents both a new approach to knowledge management research in virtual academic communities and demonstrates certain rationality

and feasibility.

2 Research Design

This paper takes the typical virtual academic community—ScienceNet—as the research context, using its blogs as study examples. It employs social network analysis to encode and map the complex relationships in virtual academic communities, excavates relationships among members within the network structure, and utilizes UCINET software for data calculation. By computing centrality and influence coefficients, it identifies the importance and positional status of central and peripheral figures in research network communities. The study focuses on analyzing how member composition relationships, internal and external environmental factors, and emotional factors affect knowledge sharing in virtual academic communities, and accordingly proposes effective pathways to promote knowledge sharing and sustainable development in virtual academic communities.

2.1 Data Collection and Matrix Construction

ScienceNet is a comprehensive science website supervised by the Chinese Academy of Sciences, Chinese Academy of Engineering, and National Natural Science Foundation of China, and hosted by Science Times. The website offers comprehensive functions, including ten major functional modules such as news, blogs, groups, universities, and international sections, covering eight scientific fields including life sciences, information science, and management synthesis. It primarily provides researchers and the public with fast and authoritative scientific news reporting, rich and practical scientific information services, and an interactive network platform, with the goal of building the most influential global Chinese scientific community.

During data collection, this study selected the persistent environmental pollution issue as the research topic. Using the popular blog post “Is Haze Caused by Uranium in Coal?” from the blog submodule of ScienceNet as an example, the study captured 74 replies posted between December 10, 2015 and December 29, 2015. After removing duplicate posts, 45 posts were organized. These 45 individuals were assigned serial numbers from 0 to 44 in alphabetical order. We assumed that interaction behavior between posts was recorded as 1, and no interaction as 0, with rows representing posters and columns representing responders, designing a 45×45 matrix. A partial screenshot of this matrix is shown in Table 1 :

This blog post titled “Is Haze Caused by Uranium in Coal?” was written by Professor Dai Shifeng from China University of Mining and Technology. The article corrected the erroneous viewpoint circulated on social media in late November 2015 by physics doctoral student Ma Ke’an that “the cause of haze formation is uranium in coal burned in northern China.” Dr. Ma Ke’an believed that haze was caused by uranium elements in northern coal combustion, and that uranium

was a major factor causing lung cancer. This viewpoint created significant public reaction on social media, caused psychological panic among the public, and to some extent triggered a public crisis. Therefore, the publication of this blog post was crucial for effective public opinion guidance. During its argumentation, the post cited 23 references, fully utilizing the author's physics and mining knowledge to analyze and discuss the causes of haze from multiple levels and dimensions, ultimately concluding that uranium content in air is minimal and that uranium is not associated with lung cancer incidence.

Among the 74 related replies and comments following the blog post, most participants were university professors or researchers from scientific institutions. Reviewing all replies provides numerous rational hypotheses about haze causes and scientific theories and data on uranium formation and disappearance. This fully demonstrates that in today's rapidly developing virtual academic communities, researchers focusing on the same field can leverage this platform to achieve knowledge flow and sharing, keep up with relevant research progress in their field at any time, enable rapid dissemination of scientific knowledge, and avoid the drawbacks of knowledge update delays and high communication costs caused by offline spatiotemporal restrictions.

2.2 Data Processing and Analysis

The numbered matrix was imported into UCINET software for graphical analysis. As shown in Figure 1 [Figure 1: see original paper], individuals numbered 7, 18, and 19 are central figures in the replies to this blog post. They are active members in the network community, enjoy high attention in this virtual academic community, and have become "expert" roles that can gain the followership and attention of most members.

Figure 1 Network Community Diagram of Virtual Academic Community

As shown in Figure 1, members in this virtual academic community are connected to varying degrees, with no isolated points present. To better determine the importance of each member and their role positioning in this virtual academic community, we further calculated centrality and influence coefficients for all members. Members with the highest centrality and influence coefficients are the central figures in the virtual academic community, namely opinion leaders. Among these, out-degree represents members' visits to others, while in-degree represents members being visited by others. Table 2 presents the centrality calculation results for some members; those not listed have very low in-degree and out-degree and were omitted due to space limitations. Table 2 shows that individuals 7, 18, and 19 have significantly higher in-degree than other members, indicating that posts published by these three individuals receive high attention and they are active members in this virtual academic community. Member 15 has relatively high in-degree but low out-degree, suggesting many people follow his posts while he pays little attention to others' posts. Member 29 has high out-degree but low in-degree, indicating he pays more attention to others' posts

in the virtual academic community, but receives less attention to his own posts. Out-degree and in-degree represent the status and influence of each member in the virtual academic community.

Can we then directly conclude that individuals 7, 18, and 19 are opinion leaders in the virtual academic community based on centrality calculation results? Obviously, this would not be scientific, as not all active members are opinion leaders—further verification is needed. This study further calculated influence coefficients for members 7, 18, and 19, as shown in Table 3. The influence coefficient can reflect the degree of influence of central figures in virtual academic communities. Only when members' statements receive widespread response from other members can they stand out from the complex network structure. When they gain recognition from the majority of members, they can to some extent guide online public opinion and promote knowledge sharing. Generally, central figures process information and disseminate it to a broader audience, guiding followers' attitudes and behaviors toward knowledge sharing. Among these, response value represents interaction relationships among members, while recognition value represents consistency in viewpoints expressed by members. Response and recognition values are compiled based on post content and quantity to derive specific numerical values, and the influence coefficient is calculated as the ratio of recognition value to response value [13].

Research results show that although participant 7 has a relatively high response value, both recognition value and influence coefficient are low, indicating that while he is relatively active in this virtual academic community, he has fewer followers, and other members may respond to him merely to correct his incorrect statements. In contrast, the calculation coefficients for member 18 show that his response and recognition values are the highest, with a relatively high influence coefficient as well. Member 19 has the highest influence coefficient, with relatively high response and recognition values. Through verification, mainstream opinion members 18 and 19 both collected substantial data and reviewed numerous literature sources to provide powerful refutations and arguments against Dr. Ma Ke'an's viewpoint that haze causes lung cancer. During this process, opinion leaders and their followers listed numerous references and cited much scientific knowledge about haze and uranium elements, enabling many members with limited understanding to obtain substantial useful information. This demonstrates that in the process of knowledge sharing, figures with higher centrality play greater roles, achieving knowledge flow and sharing in a short time within virtual academic communities.

3 Factors Influencing Knowledge Sharing in Virtual Academic Communities

With the rapid development of the internet, people can communicate in real-time through various social networks. While breaking geographical and temporal constraints, information has entered the “big bang” era. Information flow and knowledge sharing have become the foundation for virtual community devel-

opment. This research focuses on virtual academic communities, whose greatest characteristic is academic nature. Therefore, effective knowledge flow and sufficient knowledge sharing can promote the sustainable development of virtual academic communities. However, in other academic communities, people often observe insufficient knowledge sharing and low member activity, with some even calling such academic communities “zombie groups” that exist in name only. So how can we motivate member interaction, promote effective knowledge flow, and achieve knowledge sharing? The primary issue is to study the factors influencing knowledge sharing in virtual academic communities and design effective pathways to promote sustainable knowledge sharing accordingly.

In Part 2, this study analyzed cases using social network analysis methods and identified opinion leaders through a series of calculations. Through case result analysis, it is not difficult to find that nodes in the network change dynamically, and relationships among members vary with environmental changes. To identify development patterns of virtual academic communities, the author will further deduce influencing factors and construct a member relationship model, with specific analyses as follows:

3.1 Member Composition Factors

F. Lin et al. [14] found through research that knowledge flow in virtual communities is discontinuous and that knowledge sharing is formed on the basis of mutual exchange among members. Therefore, member composition type is the primary factor affecting knowledge sharing. Regarding research on member composition in virtual communities, scholars have different classifications based on their research perspectives. Representative research includes: Mao Bo et al. [15] classifying virtual community users into five types—leaders, responders, browsers, sharers, and learners—based on contributions of articles published by virtual community users to the overall knowledge formation and sharing process; J. Jiang [16] et al. categorizing members into senior scholars and junior scholars based on their educational background and professions; and Qiu Junping et al. [17] dividing members into strength-type, active-type, and peripheral-type based on SNA research.

Combining relevant research from these scholars and conclusions drawn from social network analysis above, this study classifies members of virtual academic communities into four types: knowledge contributors, opinion leaders, active members, and learners. Researchers are the backbone of virtual academic communities, and due to differences in research fields, different academic communities contain different types of researchers. Knowledge contributors are generally researchers willing to share and provide knowledge; they are the suppliers of knowledge. Therefore, how to enhance knowledge suppliers’ willingness and promote high-quality knowledge contribution is a key factor affecting knowledge sharing and transfer. Opinion leaders are authoritative experts who promote effective knowledge flow and sharing through their comments and evaluations. Active members are generally followers who interact frequently and post fre-

quently; through repeated exchange they can promote knowledge evolution and thus have opportunities to achieve knowledge innovation. Learners are generally members who silently browse or only download relevant literature and rarely speak in virtual academic communities. Through a period of learning, they may transform into the first three types or may remain learners. Through interaction among them, knowledge transfer, processing, transfer, and sharing are achieved. Members also adjust dynamically according to changes in knowledge provided by virtual academic communities. Due to the blurred boundaries of virtual academic communities, members can flow freely, but the basic types remain unchanged. The specific relationship model is shown in Figure 2 [Figure 2: see original paper]. This demonstrates that virtual community member composition directly affects the success or failure of knowledge sharing.

3.2 Internal and External Environmental Factors

The external environment here mainly refers to the technology, network security, and related supporting services and facilities that support the normal operation of virtual academic communities. In other words, a good virtual academic community is built on the support of computer technology and requires scientifically designed and comprehensive functional modules to promote agility in knowledge sharing. Network security is also an important influencing factor that cannot be ignored; it is necessary to protect the intellectual property rights of knowledge providers and avoid viruses and malicious software attacks that hinder knowledge exchange. Related supporting services and facilities are also external environmental factors affecting researchers' knowledge sharing. Virtual academic communities should have timely policy support and relevant authoritative scientific reporting, which can stimulate researchers' learning enthusiasm and knowledge sharing passion. Simultaneously, using big data technology to mine research areas of interest to researchers and proactively push relevant scientific knowledge can guide their attention and further knowledge exchange, ultimately achieving knowledge sharing.

The internal environment mainly refers to members' cognitive levels, values, and degree of trust. Although members consist of researchers, cognitive levels vary due to differences in educational backgrounds. To achieve sustainability in knowledge sharing, members' cognitive levels, values, and mutual trust are all internal environmental factors that affect the success or failure of knowledge sharing.

3.3 Emotional Factors

Emotional factors are also important prerequisites and main factors for knowledge sharing behavior, influencing knowledge sharing behavior [18]. Many scholars believe that emotional factors and knowledge sharing behavior show a positive correlation trend. This study incorporates emotional factors to analyze their impact on online knowledge sharing. Using the social network analysis tool UCINET 6.0, we calculated the network density and connectivity of the

online knowledge sharing network, as well as the network density and connectivity of the emotional relationship network. The calculation results are shown in Table 4 .

Table 4 Density and Connectivity of Knowledge Sharing and Emotional Relationships in Virtual Academic Communities

The calculation results of network density and connectivity in virtual academic communities show that emotional relationship network density changes from 0.1046 to connectivity 0.1046, while virtual academic community knowledge network density changes from 0.4125 to connectivity 0.3541. The consistent direction of change proves that emotional factors are indeed positively correlated with knowledge sharing. Both network density and connectivity values range from [0,1]. In other words, offline emotional relationship networks stimulate online knowledge sharing behavior. Higher emotional relationship connectivity leads to higher trust levels and more common language, creating an active atmosphere in virtual academic communities. In this process, knowledge demand drives knowledge supply, which further promotes knowledge demand. Based on the continuous transformation of supply-demand relationships, knowledge evolution and sharing are achieved.

4 Constructing Knowledge Sharing Pathways in Virtual Academic Communities

Through the influencing factor analysis above, we find that member composition, internal and external environments, and emotional factors all affect knowledge sharing in virtual academic communities. Knowledge can only maximize its value through transfer, exchange, and sharing. To maximize knowledge sharing in virtual academic communities and promote their sustainable development, this study designs a knowledge sharing pathway for internal and external collaborative development based on influencing factor analysis, with the member composition relationship model at its core, combined with environmental and emotional factors. The internal mechanism mainly includes trust mechanisms, fan models, incentive mechanisms, and social networks; the external mechanism includes big data technology, mobile apps, knowledge quality supervision, and service policies. The core module uses social network analysis to excavate internal relationships and dynamic change patterns among members. The specific sharing pathway is shown in Figure 3 [Figure 3: see original paper]. The following sections will analyze in detail the effective pathways and strategies for promoting knowledge sharing among members in virtual academic communities.

4.1 Improving and Popularizing Virtual Academic Community Sharing Platform Applications

To enable researchers to communicate anytime, learn from each other, and thereby achieve knowledge sharing, the first step is to properly construct and popularize virtual academic community platforms. The development of China's

virtual academic community platforms from theory to practice needs to be deepened. However, social networking platforms are widely used, with over 80% of internet users utilizing social networking software such as QQ, WeChat, and Weibo. Therefore, we can leverage social networking platforms while using big data technology to mine research areas of interest to researchers, customizing and sending them relevant research platform links. Virtual academic communities should be vigorously promoted to attract scholars' attention and increase user stickiness. When virtual academic communities achieve the same level of attention as other social networks, people in different positions within the network community can all play active roles, greatly promoting academic exchange and knowledge sharing among members in virtual academic communities.

Simultaneously, mobile apps for virtual academic communities should be developed, as the mobile internet era has shifted user habits to mobile phones. Virtual academic communities can choose to develop their own apps or cooperate with other social network clients to establish public accounts that push scientific information to attract members in the field to form academic discussion groups. Based on extensive popularization of virtual academic community platform applications, corresponding service auxiliary functions should be established, such as pushing scientific hotspot news and national policy documents in scientific fields, which can increase members' platform usage frequency. Of course, while knowledge contributors provide knowledge, an audit function must be incorporated to ensure knowledge quality, as knowledge quality directly affects dissemination and transformation effectiveness—therefore, quality supervision cannot be overlooked. The above elaborates on the main contents included in the external mechanism. Only with effective support from external software and hardware technical environments and strict knowledge quality supervision can we further develop knowledge dissemination and sharing in virtual academic communities.

4.2 Implementing Online-Offline Synchronized Knowledge Sharing Models

From the emotional factor analysis results in the previous section, we found that offline emotional relationships affect online knowledge sharing. Therefore, this study incorporates social networks and trust mechanisms into the internal mechanism design. These two elements have a mutually reinforcing relationship. When scholars already know each other offline—for example, having communicated at annual academic conferences in various fields or understanding each other's research achievements through literature reading—and further connect through social platforms, this may strengthen mutual trust and create stronger willingness to communicate in virtual academic communities, thereby accelerating knowledge evolution and sharing. On the other hand, with effective support from external technical environments, network environment security can be ensured. Simultaneously, incorporating knowledge quality supervision links ensures protection of intellectual property rights for knowledge contributors

and members during knowledge transformation, thereby strengthening trust relationships among members. Once good trust relationships are established, they can directly affect members' sense of belonging to virtual academic communities, increase members' platform usage frequency, and further strengthen members' willingness to share knowledge. Therefore, through the integration of online and offline social networks and the establishment of trust mechanisms, we can achieve synchronized online-offline models for researchers' academic achievements and knowledge sharing, promote real-time academic exchange, and drive scientific innovation.

4.3 Adopting Follower Model and Implementing Real-Name Registration

Another aspect of the internal mechanism is the adoption of the Follower Model, also known as the fan model, which refers to members following developments in the same field and being able to join groups voluntarily, becoming fans who keep up with the latest research progress of peers at any time [19]. The fan model is relatively mature in social networking platforms, and its development model can be introduced into virtual academic communities. Fans can enhance the “gold content” of knowledge contributors' accounts through methods such as sending flowers and badges. The influence factor of knowledge contributors in virtual academic communities is calculated based on this account gold content, and this influence factor is used as one of the indicators for evaluating researchers' performance and scientific research strength in real life. This incentivizes scholars to not only focus on improving their own academic literacy but also actively share and contribute their knowledge and experience with peers or relevant parties, thereby expanding their academic influence. This can be described as a mutually beneficial collaborative approach. Simultaneously, comprehensive implementation of real-name registration can constrain the publication of false academic information and personal attacks arising from academic discussions. This model encourages researchers to transform from opinion leaders, active members, and learners into knowledge contributors, enabling sustainable knowledge sharing in virtual academic communities. Therefore, adopting the Follower Model and real-name registration is an effective pathway to promote knowledge sharing in virtual academic communities.

4.4 Innovating Knowledge Sharing Incentive Mechanisms and Leveraging Opinion Leader Roles

Effective incentive mechanisms play a crucial role in any organization in society. To achieve sustainable development, virtual academic communities must include incentive mechanisms in their internal systems. Scientific research cooperation and discussion are not inherently entertaining, so it is important to combine spiritual incentives with material rewards to stimulate researchers' enthusiasm and enjoyment of their work. To enhance members' willingness and behavior regarding knowledge sharing in virtual academic communities, the contribu-

tions of members in knowledge sharing should be fully considered during the knowledge sharing process, with evaluations conducted according to contribution magnitude and knowledge contribution awards established. This provides principled and well-founded incentives for team members.

Using the virtual community member account gold content mentioned in the fan model as an indicator for offline evaluation of researchers, young researchers seeking professional promotion offline will actively participate in online academic exchanges to increase their evaluation scores. Professors and scholars who already have senior professional titles will also actively discuss their research insights and gains in forums to improve academic visibility and realize personal value. This enables knowledge to flow and be shared rapidly within a high-level group, allowing group wisdom and cohesion to generate greater value from existing knowledge and achieve offline transformation of knowledge achievements, thereby realizing their commercial value.

Opinion leaders, as core figures in the team, directly affect the effectiveness of knowledge sharing throughout the forum. Knowledge sharing cannot be achieved by knowledge contributors alone in virtual academic communities; opinion leaders hold important value in knowledge sharing. Their opinions directly affect whether knowledge is disseminated and evolved, and also influence the efficiency of knowledge sharing. Therefore, reasonable spiritual and material incentives for opinion leaders are necessary, such as inviting certain opinion leaders from virtual academic communities to share with the entire team through online conferences, video lectures, and other means. This enhances opinion leaders' influence in the forum while strengthening their sense of responsibility and satisfaction [20], thereby maximizing the role of opinion leaders to promote the scientific level and activity of the entire research forum, stimulate active member participation, provide good guidance for learners, and ultimately achieve knowledge sharing among members.

5 Conclusion

In today's rapidly developing networked environment, various social platforms have emerged, transforming people's communication methods, breaking spatiotemporal constraints, and causing information to grow explosively. Virtual academic communities have arisen in this context, and the application of this platform enables researchers to achieve academic exchange across time and space, providing an effective platform for knowledge sharing and innovation. The most important characteristic of virtual academic communities is their academic nature. How to promote academic exchange within communities and achieve functions such as knowledge dissemination, evolution, and sharing is currently a focal concern for scholars.

This paper first used a typical case from ScienceNet, employed social network analysis to identify opinion leaders in virtual academic communities, and by calculating centrality and influence coefficients, further excavated member com-

position structure and designed a member relationship model. On this basis, it analyzed factors influencing knowledge sharing in virtual academic communities, and finally constructed an effective pathway model for knowledge sharing based on these influencing factors. As an emerging phenomenon, we should pay attention to and actively participate in the growth of virtual academic communities. Virtual academic communities possess the advantages of collective wisdom and knowledge sharing, and are expected to break traditional research achievement publication and evaluation systems in the future, achieve interaction with other social networks, and become a platform for researchers worldwide to instantly share and exchange the latest information. Therefore, using social network analysis to study knowledge sharing in virtual academic communities facilitates visual analysis of academic personnel in virtual communities, while enabling rapid dissemination and evolution of knowledge through network platforms, providing opportunities for researchers to seek cooperation and thereby promoting scientific innovation. In the future, the author will use big data technology to predict future scientific research hotspots based on research priorities that researchers focus on, customize and push research information, establish a knowledge sharing evaluation system, and explore long-term mechanisms for knowledge sharing in virtual academic communities.

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Author Contributions

Qi Kai: Responsible for overall paper structure and writing; Zhang Zimo: Responsible for case selection and social network analysis application.

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Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.