Research Structure and Development Trends of International Knowledge Networks (Postprint)

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Abstract

[Purpose/Significance] Against the backdrop of organizational networking and knowledge emerging as a core organizational element, this study aims to provide a visual understanding of the current state and development of international knowledge network research, providing an important foundation for knowledge network research and network innovation development. [Method/Process] Grounded in the philosophy and methods of scientific knowledge mapping, and comprehensively utilizing VOSviewer and CiteSpace software tools, this study examines management discipline "knowledge network" literature indexed in the Web of Science Core Collection database from 2001-2020, constructs knowledge maps, analyzes literature content, summarizes the international research status of knowledge networks, reveals research hotspots, constructs a content integration framework, and detects frontier trends. [Results/Conclusion] The study identifies four knowledge network research domains: individual domain, enterprise domain, regional domain, and professional domain, as well as four hotspot research themes: network evolution research, network architecture research, network characteristics research, and network innovation research. Based on these findings, four frontier directions are proposed: dynamic knowledge network direction, complex knowledge network direction, multi-layer knowledge network direction, and innovative knowledge network direction.

Full Text

Abstract

[Purpose/Significance] Against the backdrop of organizational networking and the emergence of knowledge as a core organizational element, this study aims to visually map and comprehend the current state and development trajectory of international knowledge network research, thereby providing an important foundation for advancing knowledge network studies and network-based

innovation. [**Method/Process**] Grounded in the principles and methods of scientific knowledge mapping, this research comprehensively employs VOSviewer and CiteSpace to analyze 517 management discipline articles on "knowledge networks" from the Web of Science Core Collection database between 2001 and 2020. By generating knowledge maps and conducting literature content analysis, we summarize the international research landscape of knowledge networks, identify research hotspots, construct an integrated content framework, and detect emerging frontiers. [**Result/Conclusion**] The analysis identifies four research domains—personal, enterprise, regional, and professional knowledge networks—and four prominent research themes: network evolution, network architecture, network characteristics, and network innovation. Based on these findings, we propose four frontier directions: dynamic knowledge networks, complex knowledge networks, multi-layer knowledge networks, and innovative knowledge networks.

Keywords: knowledge network; knowledge map; cluster analysis; research hotspots

Introduction

Grounded in the knowledge-based view, knowledge represents a critical strategic resource for competitive advantage. Modern enterprises increasingly depend on internal and external knowledge resources for survival and development [1]. To respond to constantly changing economic and institutional environments, firms must learn from external sources and create new knowledge, necessitating their participation in systems that enable direct contact with other actors for knowledge exchange—in other words, knowledge networks [2]. The scientific literature has reached consensus on the vital role networks play in knowledge production, transformation, and circulation. Compared to other networks, knowledge networks are more abstract, representing an excavation of valuable tacit resources embedded in people' s minds. Knowledge networks provide participating actors with an environment for information sharing, enhancing their ability to acquire, create, disseminate, absorb, and utilize information, thereby facilitating innovation development, performance improvement, and value creation.

Overall, knowledge network research has developed rapidly internationally and yielded fruitful results, making timely tracking and analysis of relevant literature necessary. Moreover, due to the intangible and abstract nature of "knowledge" itself, knowledge network research exhibits considerable variation across studies, requiring systematic review and synthesis. Knowledge networks represent an interdisciplinary research domain, yet current bibliometric studies of knowledge networks concentrate primarily on library and information science, with scarce attention to management discipline knowledge networks. Therefore, this study focuses on the management discipline, first retrieving and summarizing relevant literature, then systematically analyzing the research foundation, do-

mains, themes, and trends of international knowledge network research through combined content analysis and scientific knowledge mapping, and finally presenting an integrated framework to clarify directions for future domestic knowledge network research.

Methodology

The English literature data for this study were sourced from the SSCI citation index sub-database of the Web of Science Core Collection, covering 2001–2020. The search query was set as TS=("Knowledge network* "), with" Article" as the document type and "MANAGEMENT," "BUSINESS," and "ECONOMICS" as the subject categories. After screening the retrieval results, 517 English articles were obtained as the research sample.

This study primarily employed VOSviewer 1.6.16 and CiteSpace 5.7.R5 for systematic analysis. VOSviewer extracts high-frequency knowledge units, constructs and visualizes unit data, and comprehensively draws thematic clustering maps for a research field [3]. CiteSpace combines citation and temporal analysis, using burst detection and timeline algorithms to predict research frontiers. This paper uses burst word analysis and timeline analysis of the sample literature to identify emerging directions.

Research Foundation Analysis

Highly cited literature represents theoretically significant and widely recognized classic works that constitute the core content and research foundation. This study selected the top 10% of articles by total citation frequency from the 517 sample articles for content analysis, comparing them with the top 10% of Chinese articles by total citation frequency from CNKI to systematically review knowledge network concept definitions.

As an interdisciplinary research domain, knowledge networks are often regarded as a special component of social networks and categorized within sociology. As theoretical systems have matured, scholars have applied knowledge networks in multiple contexts. From a management perspective, the focus is primarily on knowledge networks as a management tool to compensate for organizational deficiencies. From a value perspective, knowledge networks are viewed as knowledge interaction platforms among multiple actors, emphasizing participating individuals or organizations. From a link perspective, definitions focus on the composition of knowledge networks. From an evolution perspective, time is emphasized, treating knowledge network formation as a dynamic process. Representative scholars and their conceptual definitions from these main perspectives are shown in Table 1 .

Research Domain Analysis

Through content analysis of 127 highly relevant articles, this study identifies the main domains of knowledge network research. Based on differences in the scope of knowledge network actors, research domains are divided into four areas: personal knowledge networks, enterprise knowledge networks, regional knowledge networks, and professional knowledge networks.

Combined with literature content, enterprise knowledge networks represent the core research focus. Enterprise knowledge networks consist of a three-level framework: the innermost level comprises enterprise employees or teams completing common tasks; the middle level consists of other employees, teams, or departments; and the outermost level includes government, customers, suppliers, research institutions, partners, and competitors [4]. Consequently, the enterprise knowledge network domain further divides into four sub-domains: employee knowledge networks, team (department) knowledge networks, university-industry knowledge networks, and cluster knowledge networks.

Personal knowledge network research primarily focuses on two aspects: first, integrating knowledge networks with personal knowledge management (PKM), which represents a bottom-up approach to traditional knowledge management tailored to individual knowledge workers' needs. Personal knowledge networks provide a knowledge repository to assist individuals in PKM and knowledge creation. Second, combining knowledge networks with individual learning, viewing personal knowledge networks as a tool for individual learning and examining how to utilize this tool more efficiently.

Enterprise knowledge network research addresses diverse questions, including knowledge integration, knowledge creation, and knowledge sharing; open innovation and innovation performance; organizational and employee learning; and how to leverage networks for resource complementarity and heterogeneous resource acquisition. Employee knowledge network research focuses on how employee capability enhancement affects employee and enterprise performance; department knowledge networks emphasize constructing appropriate R&D and support department networks; university-industry knowledge networks examine collaboration between enterprises and universities, focusing on how "industry-university" knowledge production network structures affect regional innovation and the win-win effects of knowledge transfer and learning.

Regional knowledge network research emphasizes the impact of network knowledge flow on regional economies, examining how governments or industries utilize such sustainable development networks for learning and innovation. Professional knowledge networks refer to specific industry networks, such as green knowledge networks in ecological management or industrial knowledge networks in manufacturing. These studies primarily demonstrate knowledge network applications within professional scopes through case studies.

Research Theme Analysis

Keyword clustering analysis can reveal associations among complex concepts through modular views, thereby identifying research themes. Using VOSviewer for keyword clustering analysis of the sample literature, four clusters were ultimately identified, as shown in Figure 1 [Figure 1: see original paper]. Knowledge network research can be clustered into four major themes: network evolution research, network architecture research, network characteristics research, and network innovation research, with keywords shown in Table 2 . Network evolution explains the formation process of knowledge networks, network architecture explains actor classification, network characteristics explain structural attributes, and network innovation explains outcome effects.

(1) Network Evolution Research

This cluster primarily involves four keywords: knowledge management, knowledge transfer, knowledge diffusion, and organizational learning. Network evolution research examines the drivers of knowledge network formation and the evolution process. Scholars analyze formation drivers from multiple perspectives, including transaction costs, resource complementarity, and knowledge creation. The transaction cost perspective notes that knowledge' s public goods nature, externalities, and information asymmetry in transactions make reduced market transaction costs and internal collaboration costs through knowledge networks a formation driver. The resource complementarity perspective, based on "knowledge gaps," argues that insufficient internal knowledge supply and external environmental uncertainty lead to knowledge networks formed for knowledge sharing to compensate for organizational knowledge gaps. L. Y. Xu et al. found that knowledge network participant exchanges facilitate tacit knowledge learning and transfer, thereby compensating for enterprise knowledge gaps [14]. The knowledge creation perspective views knowledge networks as complex, dynamic, and open systems that help organizations obtain heterogeneous resources and improve knowledge creation capabilities, making network construction imperative.

The knowledge network evolution process reflects both temporal structural changes and knowledge' s fluid nature, with evolution models abstracting internal interaction processes. Qualitatively, knowledge networks operate in dynamic external environments, with evolution occurring at "micro" and "macro" levels. The micro-level views network relationships as basic components whose continuous evolution constitutes knowledge network evolution. When actors' costs and difficulties in obtaining external resources and environmental uncertainty change, affordable network relationships change, altering network scale. The macro-level manifests as systematic evolutionary trends, with knowledge networks experiencing life cycles of production, development, maturity, and decline like other networks. Quantitatively, scholars commonly employ dynamic modeling and simulation methods. N. Choudhury et al. argue that supervised learning mechanisms better predict knowledge network evolution

trends than traditional network topology and preferential attachment methods [15].

(2) Network Characteristics Research

This cluster primarily involves four keywords: network analysis, network relationships, network structure embedding, and social network analysis. Knowledge network analysis focuses on network characteristics, including structural, relational, and actor characteristics [6].

Structural characteristics refer to positional differences among actors in knowledge networks, comprising network nodes, network resources, network activities, and network environment. Scholars primarily measure these using structural holes, network size, network centrality, and network stability. Structural holes are connection gaps formed when other actors connected to a given actor are not connected to each other. Structural holes have dual effects: N. Argyro found that technology network structural holes help firms obtain diverse resources and facilitate knowledge search, but excessive technology knowledge network structural holes may weaken technological innovation due to knowledge complexity [16]. Network size measures the number of nodes and connections in an actor' s knowledge network; larger networks contain more actors and resources, but excessive size increases construction and maintenance costs while raising information screening costs. Network position centrality measures an actor' s location, centrality, and power within the network. Network stability refers to long-term, stable cooperation among network actors—a dynamic stability.

Relational characteristics refer to features of knowledge exchange relationships between actors, primarily measured by tie strength [17]. Ties are divided into strong and weak ties. Strong tie research involves knowledge sharing, openness, and relationship durability, while weak ties reduce resource redundancy and enhance information heterogeneity. Some scholars argue that strong ties enhance mutual trust and improve knowledge flow efficiency, thereby improving performance; others counter that excessive tie strength leads to network dependence, network inertia, reduced heterogeneous resources, and negative effects. Some propose an inverted U-shaped relationship between knowledge network tie strength and firm performance, advocating weak tie theory, with different effects across network levels. Academia generally agrees both weak and strong ties effectively enhance firm capabilities, depending on network context.

Actor characteristics refer to differences among knowledge network actors themselves. Actors differ in geographic location, social background, and knowledge base, bringing heterogeneous resources but also increasing cooperation costs and knowledge absorption difficulty. This requires firms to possess broad knowledge bases and strong absorptive capacity. S. Juhász studied cluster knowledge network evolution, finding that while distance provides new knowledge, most learning occurs in proximate spatial ranges where existing social ties reduce transaction costs and improve learning efficiency [18]. When external knowl-

edge is highly applicable to a firm' s own knowledge, the firm more readily accepts existing network ties with high opportunity costs, but when new knowledge search costs and uncertainty are low, firms are more likely to seek new ties. Thus, actor characteristics affect not only knowledge absorption and utilization but also network formation, evolution, and expansion.

(3) Network Architecture Research

This cluster primarily involves four keywords: social networks, organizational networks, knowledge search, and collaboration. Research on network architecture first classifies knowledge networks, then studies single-level networks, and with deepening research, scholars begin nesting different network levels to examine multi-level network interactions. Using knowledge network node forms and inter-node relationships as classification criteria, scholars categorize knowledge networks into three types: networks between knowledge elements, networks between knowledge and knowledge-bearing personnel, and networks among personnel, teams, enterprises, and other knowledge actors [19]. The third type receives the most research attention, further divisible into personal knowledge networks, organizational knowledge networks (including groups and companies), and social knowledge networks (including alliances and associations). Thus, actor knowledge network architecture can be single-level or formed through multi-level network interactions.

Organizations are multi-level relational systems. Nodes at lower levels are nested in higher-level collectives, which themselves are networks of lower-level nodes. Scholars differentiate knowledge networks by level, finding that different-level knowledge networks provide different knowledge elements to enterprises, with varying costs and difficulties in knowledge digestion, absorption, and collaborative integration. However, most knowledge network architecture research focuses on single analytical levels. To meet theoretical and practical demands, some scholars conduct research from multi-level perspectives. M. Pu et al., using foreign subsidiaries' dual knowledge network embedding as a research perspective, found that internal networks share group common activities while external networks enhance subsidiaries' exploitation of host country market opportunities [20]. Existing research has established multi-layer embedded knowledge networks' roles in capability building, importance, and auxiliary impacts. With the knowledge economy' s development, scholars have shifted embedded network research focus toward innovation development, R&D efficiency, knowledge adaptation and sharing, and organizational learning.

(4) Network Innovation Research

This cluster primarily involves four keywords: knowledge sharing, innovation, open innovation, and exploration. In studying knowledge network-innovation behavior relationships, scholars primarily examine influencing factors, mechanisms, and contribution mechanisms (antecedents, mediation, and outcomes).

Influencing factors research primarily focuses on characteristics, often combined with network characteristics research. It generally holds that knowledge networks' structural, relational, and actor characteristics differently affect innovation, with variations in structural hole numbers, network size, centrality, and tie strength leading to knowledge innovation differences. For example, when examining tie strength as an influencing factor, strong ties' advantages in organizational trust and relationship durability affect incremental innovation, while weak ties' advantages in resource heterogeneity and flow efficiency affect radical innovation. H. Berry explored how different knowledge network embeddedness affects knowledge search and innovation outcomes, finding different high-low embeddedness preference combinations for incremental versus radical innovation [21].

Mechanism research primarily focuses on pathways. Under technological innovation systems theory and networked technological innovation process models, research on enterprise networks' impact on technological innovation has developed rapidly, with increasing scholars finding that knowledge activities in networks are key factors affecting enterprise technological innovation performance. Knowledge network research has deeply examined how network relationships affect knowledge creation, acquisition, and utilization. Early research focused on knowledge networks' technical support for knowledge sharing, subsequently emphasizing knowledge networks' roles in knowledge sharing, transfer, absorption, application, and creation activities to enhance technological innovation [22]. C. Y. Lee et al. used social network research methods to establish knowledge network boundaries, finding that knowledge networks improve enterprise innovation performance by enhancing knowledge integration capabilities [23].

Contribution mechanism research primarily focuses on performance. Knowledge network-innovation research covers extensive scope, including team innovation performance, individual innovation performance, industrial technological innovation, industry-university-research combination innovation, multinational corporation innovation capabilities, and innovation system construction. S. Najafi-Tavani et al. argue that knowledge networks improve enterprises' ability to acquire complementary resources, promote explicit and tacit knowledge exchange, and reduce information acquisition costs and R&D risks [24]. Firms in different cluster positions acquire heterogeneous knowledge, making knowledge networks key to understanding innovation pattern structures. With the rise of the knowledge economy and sharing economy models and changes in global industrial chain competition, knowledge networks have become important platform channels, attracting increasing researcher attention to knowledge networks' impact on innovation performance at different levels.

Research Framework

Through content and visual analysis of 517 management discipline knowledge network articles from the Web of Science database, this study summarizes a knowledge network research framework, as shown in Figure 2 [Figure 2: see

original paper]. The inner layer represents knowledge network research domains. During knowledge network research development, four domains have formed: personal knowledge networks, enterprise knowledge networks, regional knowledge networks, and professional knowledge networks, with further subdivisions including employee knowledge networks, team knowledge networks, university-industry knowledge networks, and cluster knowledge networks. Scholars have gradually deepened research across these domains.

The outer layer in Figure 2 divides knowledge network research themes into four categories through thematic clustering: network evolution research, network architecture research, network characteristics research, and network innovation research, each containing multiple research directions. Network evolution research includes studies on evolution drivers, mechanisms, and models, with drivers comprising transaction cost, resource complementarity, knowledge creation, and geographic proximity; mechanism research distinguishing micro and macro levels; and models primarily using dynamic modeling and simulation. Network characteristics research includes three types: structural characteristics (primarily measured by structural holes, network size, centrality, and stability), relational characteristics (measured by tie strength), and actor characteristics (studying how differences in knowledge base and absorptive capacity affect firms). Network architecture research has progressed gradually from network classification to single-level networks to multi-level networks. Network innovation research examines three perspectives—influencing factors, mechanisms, and contribution mechanisms—to explore antecedents, pathways, and outcomes between knowledge networks and innovation.

Research Trend Analysis

This study used CiteSpace' s burst detection algorithm to extract the top 10 high-weight burst words from sample literature titles, abstracts, and keywords (see Figure 3 [Figure 3: see original paper]). The most recent burst words from 2018–2020 are "innovation network" and "patent."

Subsequently, CiteSpace' s timeline mapping function generated a co-citation timeline map (see Figure 4 [Figure 4: see original paper]), with frontier clusters from 2018–2020 including "exploitative innovation," "knowledge flow," and "network formation."

Based on software analysis and sample literature reading, four frontier directions are identified:

(1) Dynamic Networks: Combining Temporal Dimensions and Dynamics under Network Evolution Research

Like other complex networks, knowledge networks have evolved from disorder to static order to dynamic evolution. Static knowledge network research focuses on conceptual definitions and components, such as how static knowledge networks facilitate knowledge exchange [25] and obtain otherwise inaccessible

resources and knowledge [26]. With deepening research, scholars have introduced dynamic capabilities and temporal dimensions into knowledge network studies. Networks form based on actors' knowledge acquisition and complementarity behaviors, then integrate, utilize, and recreate knowledge over time, creating dynamic network effects and greater value. Knowledge network temporal dimensions exist non-linearly, as actors can recombine previously acquired knowledge to create new knowledge, leading scholars to propose measuring dynamic knowledge network value using temporal dimensions. How to achieve value creation in dynamic network evolution represents an important future research theme.

(2) Complex Networks: Expanding Social Network Analysis under Network Characteristics Research

Current knowledge network social network analysis primarily involves centrality theory, structural hole theory, and small-world phenomena. However, social network analysis offers additional methods, such as cohesive subgroup analysis for whole networks, preference network theory, network evolution methods, and individual network theories like broker theory and reach-efficiency theory, all applicable to exploring knowledge network mechanisms. For example, identifying cohesive subgroups based on strong versus weak ties to observe subgroup evolution trends and component analysis over time, or leveraging network data advantages over attribute data for econometric model analysis. Using patents to construct knowledge networks and conducting extended analyses with such methods helps scholars better explore knowledge network mechanisms and innovation outcomes.

(3) Multi-Layer Networks: Interactive Combination of Multiple Network Types under Network Architecture Research

The decoupling perspective of knowledge networks and social networks not only compensates for existing theoretical gaps but also opens new directions for knowledge innovation research, as scholars begin focusing on nested and interacting multiple networks within enterprises. Embedding in single networks risks knowledge redundancy and technological inertia; when network tie strength reaches certain levels, network lock-in emerges, hindering new knowledge absorption and affecting value creation. Therefore, enterprise value creation and realization depend on multi-level network embeddedness. Academia has gradually shifted from single to multi-network perspectives, but research questions remain regarding optimal multi-layer network embedding strength, how to fully interactively utilize each network, and whether excessive network embedding creates knowledge leakage risks—all potential future research priorities.

(4) Innovative Networks: Combining Knowledge Networks and Innovation under Network Innovation Research

Innovation networks and knowledge networks are similar. T. Vissak et al. view innovation networks as production organizational forms existing between markets and organizations, basic institutional arrangements for solving systemic innovation problems, and means for actors to coordinate industrial R&D processes [27]. Unlike knowledge networks, innovation networks emphasize positive outcomes from knowledge flows, with nodes being more R&D-oriented individuals or organizations. In the knowledge economy context, companies establishing knowledge relationships with partners in innovation networks facilitates mutual learning and improves innovation capabilities [28]. Innovation network research can more comprehensively cover firms' market, production, management, and R&D knowledge interactions. Against the knowledge economy backdrop, how to better utilize internal and external knowledge and innovation networks has become a research hotspot.

Conclusion and Outlook

Using the Web of Science Core Collection database, this study selected 517 management discipline articles on "knowledge networks" from the SSCI citation index between 2001–2020 as samples for knowledge mapping and content analysis. The following conclusions are drawn:

During knowledge network research development, four research domains have formed: personal knowledge networks, enterprise knowledge networks, regional knowledge networks, and professional knowledge networks. Through thematic clustering, four research themes are identified: network evolution research, network architecture research, network characteristics research, and network innovation research. Through burst word and timeline analysis, four frontier directions emerge: dynamic networks, complex networks, multi-layer networks, and innovative networks.

Against the knowledge economy and sharing economy backdrop, enterprise development and innovation no longer involve closed internal exchange but require more external knowledge seeking and expansion. Knowledge network construction provides platforms and channels for knowledge acquisition and utilization at multiple levels. Furthermore, knowledge network impacts extend upward to industry and national levels and downward to departmental and individual levels. Therefore, systematic review and analysis of knowledge network research themes can better encourage domestic and international scholars to emphasize and focus on knowledge network research, thereby refining and developing knowledge network theoretical systems and assisting different actors in high-quality, efficient knowledge acquisition and innovation.

References

[1] SU J F, BAI Q, SINDAKIS S, et al. Vulnerability of multinational corporation knowledge network facing resource loss: a super-network perspective[J]. Management decision, 2021, 59(1): 84-103.

[2] GIUDICE M D, MAGGIONI V. Managerial practices and operative directions of knowledge management within inter-firm networks: a global view[J]. Journal of knowledge management, 2014, 18(5): 841-846.

[3] LI D, YU Z C, FAN Z P. Analysis of the construction process of knowledge networks[J]. Studies in science of science, 2002(6): 620-623.

[4] OWEN-SMITH J, POWELL W W. Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community[J]. Organization science, 2004, 15(1): 5-21.

[5] LI Y, SHI Z Z, TU M Z. Knowledge networks and enterprise dynamic capabilities[J]. Information science, 2006(3): 434-437.

[6] HANSEN M T. Knowledge networks: explaining effective knowledge sharing in multiunit companies[J]. Organization science, 2002, 13(3): 232-248.

[7] KONG E. The future of knowledge: increasing prosperity through value networks: Verna Allee[J]. Knowledge and process management, 2003, 10(2): 137-138.

[8] WEI J, XU L. Dual embeddedness in knowledge networks, knowledge integration, and innovation capability of cluster enterprises[J]. Journal of management sciences in China, 2014, 17(2): 34-47.

[9] WANG J. A knowledge network constructed by integrating classification, thesaurus, and metadata in digital library[J]. International information and library review, 2003, 35(2-4): 383-397.

[10] LI B Z, XU G Y, SU Y. Research on the path of team knowledge transfer risk on knowledge transfer performance—the mediating role of knowledge networks and the moderating role of team shared mental models[J]. Science research management, 2014, 35(2): 128-136.

[11] BRENNECKE J, RANK O. The firm' s knowledge network and the transfer of advice among corporate inventors—a multilevel network study[J]. Research policy, 2017, 46(4): 768-783.

[12] XIAO D P, GU X. Research on the structural evolution of knowledge networks based on self-organization theory[J]. Science & technology progress and policy, 2009, 26(19): 168-172.

[13] XIAO D P, GU X, PENG X H. Research on knowledge flow in knowledge networks from an embeddedness perspective[J]. Journal of intelligence, 2009, 28(8): 116-125.

[14] XU L Y, LI J, ZHOU X. Exploring new knowledge through research collaboration: the moderation of the global and local cohesion of knowledge networks[J]. The journal of technology transfer, 2019, 44(3): 822-849.

[15] CHOUDHURY N, FAISAL F, KHUSHI M. Mining temporal evolution of knowledge graphs and genealogical features for literature-based discovery prediction[J]. Journal of informetrics, 2020, 14(3): 57-80.

[16] ARGYRO N, LIOUKAS S, VOUDOURIS I. Network structure and firm-level entrepreneurial behavior: the role of market and technological knowledge networks[J]. Journal of business research, 2020, 106(8): 129-138.

[17] BALLAND P A, BOSCHMA R, FRENKEN K. Proximity and innovation: from statics to dynamics[J]. Regional studies, 2014, 49(6): 907-920.

[18] JUHÁSZ S. Spinoffs and tie formation in cluster knowledge networks[J]. Small business economics, 2019, 56(9): 1-18.

[19] TANG C Y, HUANG D L. A review of domestic and international research on knowledge networks and creativity[J]. Science of science and management of S.&.T., 2016, 37(3): 43-49.

[20] PU M, SOH P H. The role of dual embeddedness and organizational learning in subsidiary development[J]. Asia Pacific journal of management, 2018, 35(2): 373-397.

[21] BERRY H. The influence of multiple knowledge networks on innovation in foreign operations[J]. Organization science, 2018, 29(5): 855-872.

[22] JUHÁSZ S, LENGYEL B. Creation and persistence of ties in cluster knowledge networks[J]. Journal of economic geography, 2018, 18(6): 1203-1226.

[23] LEE C Y, WANG M C, HUANG Y C. The double-edged sword of technological diversity in R&D alliances: network position and learning speed as moderators[J]. European management journal, 2015, 33(6): 450-461.

[24] NAJAFI-TAVANI S, NAJAFI-TAVANI Z, NAUDÉ P, et al. How collaborative innovation networks affect new product performance: product innovation capability, process innovation capability, and absorptive capacity[J]. Industrial marketing management, 2018, 73(13): 193-205.

[25] DOOLEY L, GUBBINS C. Inter-organisational knowledge networks: synthesising dialectic tensions of university-industry knowledge discovery[J]. Journal of knowledge management, 2019, 23(10): 2113-2134.

[26] GUERCINI S, MEDLIN C J. A radical constructivist approach to boundaries in business network research[J]. Industrial marketing management, 2020, 91(4): 510-520.

[27] VISSAK T, FRANCIONI B, FREEMAN S. Foreign market entries, exits and re-entries: the role of knowledge, network relationships and decision-making logic[J]. International business review, 2020, 29(1): 101-123.

[28] YUE Z M, ZHAO S K. Review and prospect of foreign innovation network research[J]. Science and technology management research, 2020, 40(21): 31-45.

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