# Research on Knowledge Flow Patterns within Entrepreneurial Ecosystems under Different Governance Structures (Postprint)

**Authors:** Yang Yi, Lü Jia, Ma Hongjia

**Date:** 2023-04-01T16:02:44+00:00

## Abstract

[Purpose/Significance] In recent years, the entrepreneurial ecosystem has become a hot topic in entrepreneurship research; however, studies exploring knowledge flow from the perspective of entrepreneurial ecosystem governance models remain relatively scarce. Therefore, by examining the characteristics of inter-firm knowledge flow under different governance models of entrepreneurial ecosystems, this study aims to promote firms' own innovation and the diffusion of innovation outcomes, thereby driving the healthy development of the entire entrepreneurial ecosystem. [Method/Process] Combining the evolutionary process of entrepreneurial ecosystem governance models, this paper defines the entrepreneurial ecosystem, its governance models, and knowledge flow, proposes hierarchical governance models and relational governance models for different development stages of entrepreneurial ecosystems, and constructs inter-firm knowledge flow models under different governance models, namely, the knowledge flow model under hierarchical governance and the knowledge flow model under relational governance. [Results/Conclusions] Under the hierarchical governance model of entrepreneurial ecosystems, knowledge flow forms a knowledge supply chain; when the governance model lies between hierarchical and relational governance, knowledge flow transitions from a knowledge supply chain to a knowledge network; when the governance model is relational governance, knowledge flow directions exhibit diversified characteristics, forming a knowledge network.

## Full Text

# Research on Knowledge Flow Patterns in Entrepreneurial Ecosystems Under Different Governance Structures

**Yang Yi**[1], **Lyu Jia**[2], **Ma Hongjia**[3]
[1]School of Economics and Management, Dalian University of Technology, Dalian 116024
[2]School of Management, Jilin Normal University, Siping 136000
[3]School of Management, Jilin University, Changchun 130022

**Abstract:** [Purpose/Significance] In recent years, entrepreneurial ecosystems have become a hot topic in entrepreneurship research, yet studies examining knowledge flow from the perspective of ecosystem governance remain scarce. This research investigates how knowledge flows among firms under different governance modes within entrepreneurial ecosystems to promote firm-level innovation and its diffusion, thereby fostering healthy ecosystem development. [Method/Process] By examining the evolutionary process of entrepreneurial ecosystem governance, we define key concepts and propose hierarchical and relational governance modes corresponding to different developmental stages. We construct inter-firm knowledge flow models for each governance mode: a knowledge supply chain model under hierarchical governance and a knowledge network model under relational governance. [Result/Conclusion] Under hierarchical governance, knowledge flows form a knowledge supply chain; during the transition between hierarchical and relational governance, knowledge flow shifts from supply chain to network; under relational governance, knowledge flow becomes multidirectional, forming a knowledge network.

**Keywords:** entrepreneurial ecosystems; governance mode; knowledge flow; hierarchical governance; relational governance

---

## 2 Literature Review

### 2.1 Concept of Entrepreneurial Ecosystems

Following J. Valdez's [3] initial coining of the term "entrepreneurial ecosystem" in 1988, J.F. Moore [12] and R. Adner [13] extended the biological ecosystem metaphor to management studies in 1993 and 2006, introducing "business ecosystems" and "innovation ecosystems" respectively. Moore [12] argued that firms in business ecosystems co-evolve and innovate continuously through cooperation and competition, developing new products to meet consumer demands. Innovation ecosystems emphasize complementarity and interdependence, positing that such ecosystems are built around core technologies or internet platforms that create significant value through linkages among complementors, suppliers, distributors, and focal firms [14].

In contrast, entrepreneurial ecosystems emphasize cultivating and supporting

entrepreneurial activities [15], with definitions focusing more explicitly on entrepreneurship. Isenberg [16] defined entrepreneurial ecosystems as environments where entrepreneurs can readily access human capital, funding, and expertise, benefit from policy incentives, and operate in a culture tolerant of failure. Roundy [17] conceptualized them as geographically bounded systems comprising individuals, organizations, material resources, social structures, and cultural values that facilitate new venture creation. Cai Li and Peng Xiuqing et al. [18] identified six key characteristics: diversity, network structure, symbiosis, competition, self-sustainability, and regional boundedness.

Scholars have further refined ecosystem typologies. Cohen [19] proposed "sustainable entrepreneurial ecosystems" that drive economic development by supporting new venture creation and sustainability, focusing on the sustainable development of geographically bounded, interconnected participant communities. "Digital entrepreneurial ecosystems" integrate digital and entrepreneurial ecosystems, offering a conceptual framework for understanding entrepreneur-consumer relationships in the digital age [20]. Entrepreneurial ecosystems also emphasize spatial boundedness, operating at various scales—from cities to regions or provinces, sometimes characterized as "nested regions" where participants interact across multiple spatial scales [21], or even within smaller boundaries like university campuses [22].

The entrepreneurial ecosystem approach has become a new paradigm in entrepreneurship research, emphasizing interdependencies among multiple elements and actors rather than focusing solely on individual entrepreneurs [23]. Over time, ecosystems generate new ventures through interactions among interdependent components [24]. While no unified definition exists, scholars largely agree that essential elements include investment capital, producers, universities and research institutions, supportive culture, robust business infrastructure, support services, and public policies encouraging entrepreneurship [1, 25]. These elements influence local venture growth and competitiveness by promoting cooperation, information sharing, knowledge spillovers, and opportunity recognition [1]. A common feature across ecosystems is network formation and knowledge exchange among participants [2], operating within spatial boundaries that create interdependencies and ultimately generate new value [2].

### 2.2 Governance of Entrepreneurial Ecosystems

Interactions among different institutions and participants in entrepreneurial ecosystems create governance challenges, including conflicts over resource allocation and distribution of benefits and costs. Effective internal governance mechanisms are crucial for ecosystem self-sustainability [18]. Addressing these challenges requires first determining whether ecosystems evolve spontaneously or require deliberate intervention—and if the latter, who governs and who makes the rules.

Two perspectives on ecosystem evolution exist: bottom-up and top-down [26]. Bottom-up evolution occurs when ecosystems develop spontaneously over time through an invisible hand mechanism, like Darwinian survival of the fittest, without policy intervention [26]. Top-down evolution requires deliberate intervention, raising urgent questions about resource allocation, benefit distribution, and management within the ecosystem.

Most scholars believe ecosystem governance can be improved through deliberate measures, such as establishing research joint ventures to reduce risks for ecosystem participants and improve performance [27], appointing project managers for publicly funded research initiatives [28], or focusing on effective governance of key stakeholders to ensure desired outcomes [29]. Rampersad [29] linked governance processes to performance outcomes, examining how effective governance can enhance participant performance. Stam [15] argued that governance policy should not maximize a single entrepreneurial metric but rather create environments and institutions where productive entrepreneurship can flourish.

Colombelli et al. [11] identified two primary governance modes—hierarchical and relational—building on Tracey et al.'s [30] cluster governance research. Hierarchical governance relies on explicit authority patterns where core actors dominate rule-making, while relational governance involves cooperation norms and routines co-defined and adjusted by all participants. They mapped the evolution of these modes across the ecosystem lifecycle [11]. This paper adopts Colombelli et al.'s framework to examine knowledge flows within entrepreneurial ecosystems.

### 2.3 Knowledge Flow Within Entrepreneurial Ecosystems

Knowledge differs from traditional economic resources in two fundamental ways: non-excludability (others cannot be prevented from accessing and using it) and inexhaustibility [31]. Consequently, knowledge exhibits a high propensity for spillovers [32], attracting scholarly attention to knowledge flows.

Scholars have analyzed knowledge flow from various perspectives. Zhuge [33] conceptualized it as a knowledge exchange process among actors—a method of knowledge processing with three key attributes: direction, content, and carrier. The flow occurs in a two-dimensional knowledge space; carriers are nodes (senders and receivers); content is shareable knowledge [33]. Boisot [34] examined knowledge flow from a technological strategy perspective, identifying four stages: diffusion, absorption, scanning, and problem-solving. Nissen et al. [35] synthesized knowledge management process and lifecycle research into a six-stage model: creation, organization, formalization, distribution, application, and evolution. Tippmann et al. [36] used qualitative data from 40 subsidiary managers to analyze micro-practices of knowledge flow in multinational corporations, constructing a hierarchical model of flow intensity that highlighted the importance of horizontal and vertical communication.

According to knowledge spillover entrepreneurship theory, knowledge-rich envi-

ronments generate more innovation opportunities [32]. Cui Xinjian and Guo Zifeng et al. [37] viewed knowledge flow and innovation processes as inseparable, with regional knowledge flow reflecting regional innovation processes and its evolution representing upgrading regional innovation capacity. Jia Weifeng and Dang Xinghua et al. [38] argued that knowledge diffusion in technological innovation networks is simultaneously a network evolution process and a core node enterprise growth process, essentially involving boundary-crossing flow of core knowledge.

Other scholars have explained knowledge flow through knowledge supply chains and networks. Jiang Zhaohua and Long Liantang et al. [39] used knowledge supply chains to explain industrial cluster formation, demonstrating how clusters reduce external and transaction costs while creating network effects for sustained economic growth. Zhong Qi and Wang Keyi et al. [40] examined internal knowledge networks and flows from an intra-firm perspective.

Knowledge flow is a critical element of entrepreneurial ecosystems, yet few studies have analyzed it from an ecosystem perspective. This paper therefore explores knowledge flow patterns under different governance structures.

---

## 3 Knowledge Flow Models in Entrepreneurial Ecosystems Under Different Governance Structures

Knowledge flow exhibits distinct characteristics under different governance modes. This section constructs inter-firm knowledge flow models across the evolution from hierarchical to relational governance. Under hierarchical governance, knowledge flows form a knowledge supply chain; during the transition between modes, flow shifts from supply chain to network; under relational governance, flow becomes multidirectional, forming a knowledge network.

### 3.1 Birth Stage: Knowledge Flow Under Hierarchical Governance

In the entrepreneurial ecosystem's "birth" stage, hierarchical governance prevails and knowledge flows form a top-down knowledge supply chain from knowledge-advanced firms to followers. During this stage, the entrepreneurial environment emerges as different participants coalesce within a tight geographic, institutional, and relational context. The first entrants are typically mature firms (core participants) that attract related partners, new ventures, and service providers [11]. As ecosystem leaders, core participants possess superior expertise, greater influence, and stronger voice. Iansiti and Levien [41] explained that dominant firms—called keystones—establish, maintain, and provide platform access benefiting all ecosystem members while assuming leadership responsibility for continuous platform optimization to attract and retain rich, diverse members. Colombo et al. [26] similarly identified core firms as critical ecosystem managers, providing key resources and playing

vital roles in developing and exploiting new ideas and technologies created by ventures. Their market power enables them to mitigate moral hazard in resource allocation and profit distribution by establishing regulatory measures and punishing dishonest behavior.

Because core participants possess more advanced knowledge, they become knowledge suppliers. Other participants or followers need this knowledge and must access it through the ecosystem's platform, becoming knowledge users. From a knowledge flow perspective, this demand-oriented flow around a core actor connecting suppliers and users to economize knowledge forms a knowledge supply chain [43]. In the ecosystem's birth stage, the core participant serves as the supply chain's central node.

Why would core participants share knowledge? Appleyard [44] argued that the decision depends on whether expected benefits from relinquishing knowledge monopoly exceed expected costs. When benefits outweigh costs, they can further decide whether sharing is unconditional or conditional. Liu Yu and Shao Yunfei et al. [45] analyzed this from an innovation performance perspective, noting that alliances enabling knowledge sharing help firms access external resources, reduce risks and uncertainties, and build competitive advantages, thereby enhancing innovation performance. For these reasons, core participants become knowledge suppliers while others become recipients and users—a process conducive to new knowledge creation.

Colombelli et al. [11] argued that entrepreneurial ecosystems emerge from hierarchical governance where a core participant actively drives ecosystem formation through interactive processes involving various network actors. Zhuge [33] viewed knowledge flow as necessary for dynamic cognitive collaboration. Thus, analyzing cognitive collaboration characteristics reveals ecosystem knowledge flow patterns: under hierarchical governance, flow is top-down from core to followers, creating cooperative symbiosis that strengthens the ecosystem.

While ecosystems include other actors like universities, government, service departments, and investors, this study focuses on knowledge flows among firms. Figure 1 [Figure 1: see original paper] illustrates these flows, with dashed boxes separating firms from other ecosystem actors and arrows indicating flow direction (arrow width represents knowledge advancement level). In this hierarchical governance stage, knowledge flow is relatively simple, forming a top-down knowledge supply chain where core participants dominate while others occupy weaker positions. To escape this disadvantage, followers actively seek greater development space and reduce dependence on core participants, driving further ecosystem evolution. For example, Alibaba Group serves as a core participant in its local ecosystem, attracting diverse firms (finance, logistics, big data) into its supply chain [47].

### 3.2 Transition Stage: Knowledge Flow During Governance Mode Evolution

In the ecosystem's "transition" stage, governance lies between hierarchical and relational modes, and knowledge flow shifts from supply chain to network, becoming multidirectional with both top-down and horizontal flows. During this stage, complex social, cultural, political, and economic feedback mechanisms emerge that may support or hinder path-dependent processes in participant networks [11]. The ecosystem becomes established with an environment suitable for nurturing and attracting new ventures, increasing their numbers. For self-development or to escape core participant control, some ventures create their own networks to change competitive rules and counterbalance core participant influence. Some of these emerging networks gradually become powerful industry forces that may eventually replace original participants and their networks. New venture roles drive ecosystem development and evolution without requiring structural functions from a single core participant. While other actors begin occupying central network positions, core participants have not fully abandoned their roles, and governance evolves toward a more horizontal, relational design. However, hierarchical governance persists for some time due to path dependencies embedded in governance forms themselves [11].

During this transition, knowledge flow becomes multidirectional. As new participants enter and knowledge diversifies, core participants' ecosystem status weakens—they retain some influence but lose leadership capacity. New entrants depend less on core participants due to knowledge diversity. Knowledge spillovers characterize this stage, as interconnectivity among participants creates new opportunity spaces enabling mutual learning [11]. Rapid firm growth expands the innovation network, improving flow efficiency and enhancing ecosystem innovation capacity and output. Collaboration with specialized or knowledge-intensive new ventures better addresses firms' knowledge challenges, while knowledge diversity and advancement facilitate new venture formation and subsequent survival and growth [48].

As hierarchical control over knowledge spillovers weakens and other actors' roles strengthen, multiple knowledge supply chains emerge with horizontal flows between them, creating more complex inter-firm connections [39]. Figure 2 [Figure 2: see original paper] illustrates this intermediate governance stage where knowledge flow exhibits multidirectional characteristics.

### 3.3 Consolidation Stage: Knowledge Flow Under Relational Governance

In the ecosystem's "consolidation" stage, relational governance prevails and knowledge flow becomes multidirectional, forming a knowledge network. At this point, all ecosystem participants have survived and become fully embedded. Original participants have developed further in both quantity and quality, while former core participants' positions have been completely eroded, making

them ordinary members like all others. No participant holds leadership 地位 [11]. All actors are equal under relational governance, where participants collaborate in envisioning and developing innovations without dominant members, with leadership and coordination responsibilities distributed across the network [46].

For long-term survival, ecosystems must achieve dynamic self-maintenance and self-reinforcement, where knowledge flow and capability accumulation cause structural changes [18]. At this stage, innovation actors form more three-dimensional horizontal networks and complex, dense knowledge transfer networks, strengthening innovation linkages and enabling full exchange and sharing of diverse knowledge and ideas that drive regional development [49-50]. Knowledge flow characteristics evolve from chain structures to networks as chains expand [40]. Knowledge networks comprise multiple units (subsystems) that exchange and supply knowledge [39].

Figure 3 [Figure 3: see original paper] illustrates this stage: former core participants have evolved into ordinary actors, governance has become relational, and knowledge flow is multidirectional with each participant potentially serving as both sender and receiver. This relational governance mode promotes innovation and new venture creation through equal relationships among participants—a source of continuous innovation that drives ecosystem development and determines its viability and sustainability [48]. For example, in Alibaba's ecosystem, as of June 12, 2020, Hangzhou's "2020 Unicorn & Quasi-unicorn Enterprise List" identified 31 unicorn and 142 quasi-unicorn enterprises with total valuations exceeding $310 billion [51], demonstrating how core participant status fades as followers catch up and establish more equal relationships.

---

## 4 Conclusions and Future Research Directions

### 4.1 Research Conclusions

Research on entrepreneurial ecosystem governance has attracted increasing attention, yet studies on knowledge flow patterns, their stage-specific characteristics, and impacts on ecosystem evolution remain limited. To better understand knowledge flow characteristics under different governance modes and promote innovation diffusion for healthy ecosystem development, this paper constructed inter-firm knowledge flow models under different governance modes.

In the ecosystem's "birth" stage, hierarchical governance produces a top-down knowledge supply chain. Core participants attract followers whose knowledge flows from core to periphery, enabling followers to acquire advanced knowledge and profits. In the "transition" stage, governance lies between hierarchical and relational modes, and knowledge flow shifts from supply chain to network. As more followers enter, flow directions diversify and core participants' roles weaken, making flow multidirectional (both top-down and horizontal). In

the "consolidation" stage, relational governance produces diversified, multidirectional knowledge networks. Core participants become ordinary members, all actors are equal, and knowledge flow loses hierarchical characteristics as each participant can be both sender and receiver.

Entrepreneurial ecosystems emerge from hierarchical governance through collaborative efforts among innovation-oriented participants. As ecosystems evolve, core participants' positions are challenged by new entrants, though they haven't fully abandoned their roles. Further evolution equalizes all participants' status, shifting governance toward relational modes.

### 4.2 Future Research Directions

This study advances research on knowledge flow-based ecosystem evolution governance but has limitations. Future research should:

1. **Examine factors influencing knowledge flow in networks.** Analyze what factors affect inter-firm knowledge flow in entrepreneurial ecosystems, whether they facilitate or hinder flow, and how to strengthen facilitators while mitigating inhibitors to enhance ecosystem innovation.
2. **Empirically test the proposed models.** While this paper constructed knowledge flow models under different governance modes, empirical validation is needed to provide practical guidance for healthy knowledge flow and innovation enhancement.
3. **Analyze knowledge complexity in greater detail.** Investigate how knowledge of varying complexity flows within ecosystems. Understanding flow mechanisms and determinants will enable managers and policymakers to more effectively influence diffusion and strengthen knowledge's role in ecosystem evolution.

---

## References

[1] SPIEGEL B. The relational organization of entrepreneurial ecosystems[J]. Entrepreneurship theory and practice, 2017, 41(1): 49-72.

[2] ACS Z J, STAM E, AUDRETSCH D B, et al. The lineages of the entrepreneurial ecosystem approach[J]. Small business economics, 2017, 49(1): 1-10.

[3] VALDEZ J. The entrepreneurial ecosystem: toward a theory of new firm formation[R/OL]. [2020-06-30]. http://www.sbaer.uca.edu/research/sbida/1988/PDF/11.pdf.

[4] AUDRETSCH D B, BELITSKI M. Entrepreneurial ecosystems in cities: establishing the framework conditions[J]. The journal of technology transfer, 2016, 42(5): 1030-1051.

[5] ADNER R. Ecosystem as structure: an actionable construct for strategy[J]. Journal of management, 2017, 43(1): 39-58.

[6] Ma Hongjia, Song Chunhua, Bi Qiang. Research on multi-level knowledge transfer model based on entrepreneurial ecosystem[J]. Library and information service, 2016, 60(14): 16-23.

[7] CARRILLO J E, GAIMON C. Managing knowledge-based resource capabilities under uncertainty[J]. Management science, 2004, 50(11): 1504-1518.

[8] OSTERLOH M, FREY B S. Motivation, knowledge transfer, and organizational forms[J]. Organization science, 2000, 11(5): 538-550.

[9] GENOME S. Global Startup Ecosystem Report 2019[EB/OL]. [2020-06-30]. https://startupgenome.com/reports/global-startup-ecosystem-report-2019.

[10] NISSEN M E. An extended model of knowledge-flow dynamics[J]. Communications of the association for information systems, 2002, 8(1): 18.

[11] COLOMBELLI A, PAOLUCCI E, UGHETTO E. Hierarchical and relational governance and the lifecycle of entrepreneurial ecosystems[J]. Small business economics, 2017, 52(2): 505-521.

[12] MOORE J F. Predators and prey: a new ecology of competition[J]. Harvard business review, 1993, 71(3): 75-86.

[13] ADNER R. Match your innovation strategy to your innovation ecosystem[J]. Harvard business review, 2006, 84(4): 98.

[14] Wang Weinan, Wu Xintong, Mei Liang. Innovation ecosystem: a contextual perspective systematic review[J]. Science research management, 2019, 40(9): 25-36.

[15] STAM E. Entrepreneurial ecosystems and regional policy: a sympathetic critique[J]. European planning studies, 2015, 23(9): 1759-1769.

[16] ISENBERG D. The entrepreneurship ecosystem strategy as a new paradigm for economic policy: principles for cultivating entrepreneurship[EB/OL]. [2020-06-30]. https://www.innovationiseverywhere.com/entrepreneurial-ecosystem-strategy-new-paradigm-economic-policy-principles-cultivating-entrepreneurship/.

[17] ROUNDY P T. Hybrid organizations and the logics of entrepreneurial ecosystems[J]. International entrepreneurship management journal, 2017, 13(4): 1221-1237.

[18] Cai Li, Peng Xiuqing, NAMBISAN S, et al. Entrepreneurial ecosystem research: review and prospects[J]. Jilin University journal social sciences edition, 2016, 56(1): 5-16, 187.

[19] COHEN B. Sustainable valley entrepreneurial ecosystems[J]. Business strategy and the environment, 2006, 15(1): 1-14.

[20] SUSSAN F, ACS Z J. The digital entrepreneurial ecosystem[J]. Small business economics, 2017, 49(1): 55-73.

[21] BROWN R, MASON C. Looking inside the spiky bits: a critical review and conceptualisation of entrepreneurial ecosystems[J]. Small business economics, 2017, 49(1): 11-30.

[22] MILLER D J, ACS Z J. The campus as entrepreneurial ecosystem: the University of Chicago[J]. Small business economics, 2017, 49(1): 75-95.

[23] Teng Tangwei. Knowledge base and frontier focus of entrepreneurial ecosystem research[J]. Management world, 2017(9): 184-185.

[24] VANDEVEN H. The development of an infrastructure for entrepreneurship[J]. Journal of business venturing, 1993, 8(3): 211-230.

[25] NECK H M, MEYER G D, COHEN B, et al. An entrepreneurial system view of new venture creation[J]. Journal of small business management, 2004, 42(2): 190-208.

[26] COLOMBO M G, DAGNINO G B, LEHMANN E E, et al. The governance of entrepreneurial ecosystems[J]. Small business economics, 2019, 52(2): 419-428.

[27] AUDRETSCH D B, LINK A N. Embracing an entrepreneurial ecosystem: an analysis of the governance of research joint ventures[J]. Small business economics, 2019, 52(2): 429-436.

[28] CUNNINGHAM J A, MENTER M, WIRSCHING K. Entrepreneurial ecosystem governance: a principal investigator-centered governance framework[J]. Small business economics, 2019, 52(2): 545-562.

[29] RAMPERSAD G. Entrepreneurial ecosystems: a governance perspective[J]. Journal of research in business, economics and management, 2016, 7(3): 1122-1134.

[30] TRACEY P, HEIDE J B, BELL S J. Bringing “place” back in: regional clusters, project governance, and new product outcomes[J]. Journal of marketing, 2014, 78(6): 1-16.

[31] ARROW K J. Economic welfare and the allocation of resources for invention[M]. Princeton: Princeton University Press, 1962.

[32] AUDRETSCH D B, KEILBACH M. The theory of knowledge spillover entrepreneurship[J]. Journal of management studies, 2007, 44(7): 1242-1254.

[33] ZHUGE H. A knowledge flow model for peer-to-peer team knowledge sharing and management[J]. Expert systems with applications, 2002, 23(1): 23-30.

[34] BOISOT M H. Is your firm a creative destroyer? Competitive learning and knowledge flows in the technological strategies of firms[J]. Research policy, 1995, 24(4): 489-506.

[35] NISSEN M, KAMEL M, SENGUPTA K. Integrated analysis and design of knowledge systems and processes[J]. Information resources management journal, 2000, 13(1): 24-43.

[36] TIPPMANN E, SCOTT P S, MANGEMATIN V. Subsidiary managers' knowledge mobilizations: unpacking emergent knowledge flows[J]. Journal of world business, 2014, 49(3): 431-443.

[37] Cui Xinjian, Guo Zifeng, Liu Yifang. Regional innovation capability evaluation based on knowledge management[J]. Economic management, 2013, 35(10): 38-47.

[38] Jia Weifeng, Dang Xinghua, Lou Xuming. Simulation research on knowledge flow control in core node formation process of technological innovation network[J]. Journal of the China society for scientific and technical information, 2017, 36(10): 1073-1079.

[39] Jiang Zhaohua, Long Liantang, Zhang Mier. Dynamic model exploration of knowledge supply chain and knowledge network under industrial cluster conditions[J]. Science of science and management of S.&T., 2004(7): 55-60.

[40] Zhong Qi, Wang Keyi, Qi Liyun. Analysis of knowledge flow based on intrafirm knowledge network[J]. Information studies: theory & application, 2008(3): 397-399, 406.

[41] IANSITI M, LEVIEN R. The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability[M]. Boston: Harvard Business Press, 2004.

[42] BHAWE N, ZAHRA S A. Inducing heterogeneity in local entrepreneurial ecosystems: the role of MNEs[J]. Small business economics, 2017, 52(2): 437-454.

[43] Cai Xiang, Yan Zongguang, Yi Haiqiang. On knowledge supply chain[J]. R&D management, 2000(6): 35-38.

[44] APPLEYARD M M. How does knowledge flow? Interfirm patterns in the semiconductor industry[J]. Strategic management journal, 1996, 17(S2): 137-154.

[45] Liu Yu, Shao Yunfei, Kang Jian. Impact of alliance portfolio configuration on firm innovation performance from knowledge sharing perspective[J]. Science & technology progress and policy, 2019, 36(21): 134-144.

[46] NAMBISAN S, SAWHNEY M. Making the most of the global brain for innovation[J]. International commerce review, 2009, 8(2): 128-135.

[47] Peng X, Cai L, Lu S, et al. Antecedent and dimension of symbiotic relationship in the hub-based entrepreneurial ecosystem: case study of Alibaba[J]. Journal of industrial integration and management, 2016, 1(4): 1650011.

[48] ZAHRA S A, NAMBISAN S. Entrepreneurship in global innovation ecosystems[J]. AMS review, 2011, 1(1): 4-17.

[49] Fang Liang, Xu Weixiang. Research on formation mechanism of innovation clusters from entrepreneurship perspective[J]. Journal of Beijing Jiaotong University (social sciences edition), 2016, 15(4): 57-64.

[50] Wang Li, You Zhujun. Simulation research on value evolution of innovation ecosystem based on knowledge flow[J]. China science and technology forum, 2019(6): 48-55.

[51] Huaxia Times. Hangzhou releases unicorn and quasi-unicorn enterprise list with total valuation exceeding $310 billion[EB/OL]. [2020-09-27]. https://baijiahao.baidu.com/s?id=1670882728782651024&wfr=spider&for=pc.

---

**Author Contributions:**

Yang Yi: Data compilation and manuscript writing
Lyu Jia: Manuscript revision and organization
Ma Hongjia: Conceptualization and supervision (Corresponding author: mahongjia@sina.com)

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