

Review of Innovation Networks Research

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Abstract. Due to the wide application of information technology, the speed of technology update is getting faster and faster. Innovation network is very important to the development of industry. So, innovation network is the hot spot of innovation research now. Through the analysis of the existing literature, this paper introduces the meaning, structural characteristics, research and development status of innovation network and the research content of innovation network evolution path. And putting forward the prospect of future research trend.

Keywords: innovation network; network structure; network evolution.

1. The Formation and Research Status of Innovation Network

The fast and volatile market environment makes the innovation network an important organizational form of enterprise technology innovation. Enterprises want to maintain a sustainable competitive advantage, they can not rely solely on their own resources, and must strengthen cooperation with other companies when building network organizations. With regard to the motivations for the formation of innovation networks, scholars have proposed different perspectives and analyzed them from different angles. From the perspective of external conditions that promote the formation of networks, De Bresson and Amesse (1991) believe that the formation of innovation networks is inseparable from external conditions, including strong technology and market uncertainty, technical system dimensions for multiple complementary technologies, and the increased excess profits of the innovation network[1]. Freeman (1991) proposed that the emergence of information technology caused changes in the technical paradigm, and ultimately promoted the establishment of innovative networks[2]. Some scholars also analyze the formation of innovation networks from the perspectives of resource base and environmental change. The resource-based view holds that pooling enterprise resources with potential for value creation is an important reason for network formation. Incomplete liquidity, imitation, and substitutability can enhance value creation and promote the formation of network alliances (Das and Teng, 2000)[3]. The formation of an innovation network is a dynamic selection process with path dependence on the initial state (Kogut, 2000)[4]. The type of network change between firms is affected by environmental changes (Koka, Madhavan and Prescott, 2006)[5]. Compared with relational embedding, when the structural embedding has more important value, the network of technological innovation network will be larger, the agglomeration will be more obvious, the average shortest distance will be smaller, and the whole network will have smaller world network characteristics (Hu Zuguang, 2010)[6]. In addition, the formation of internal and external collaborative innovation networks is also affected by the national innovation system. Under the condition that the national education system is underdeveloped, the labor market is not sufficient, and the intellectual property system is imperfect, the transaction cost of external collaborative innovation is relatively high, it is difficult for enterprises to establish more external contacts, and the collaborative innovation network is closed[7]. Zhang Lupeng (2018) believed that with the gradual deepening of innovation activities of a single enterprise to multiple vertical development, the development trend of industrial clusters gradually changed from linear development to multi-agent collaborative interaction network mode, and innovation network emerged as a new organizational form of clusters[8]. Therefore, the formation and development of the automotive industry innovation network is not only related to the complementary resource needs of the organization, but also related to the opportunities and challenges brought about by the external environment and its changes. In fact, technology, economy, society and institutional environment interact systematically to influence the evolution of the network (Kogut, 2000)[9]. Companies can respond to changes in the environment by changing the relationship between organizations (Lang and

Lockhart, 1990)[10]. However, the extent to which the environment affects the cooperative behavior of enterprises and the sensitivity of such influences is still insufficient. Cheng Yue (2011) studied the evolution of enterprise innovation networks in uncertain environments and summarized three technological evolution paths[11]. Yang yanping (2015) studied the impact of external environment of cluster innovation network from the perspective of cultural embedding. As the internal and external environment of the organization changes, the technological innovation network structure continues to evolve[12]. Liu xiaoyan (2016) analyzed the main contradictions and evolutionary inflection points in different stages of technological innovation network evolution from the perspective of evolution, and proposed the optimization strategy of network structure driven by contradiction[13]. Xiao Yao (2017) studied the governance methods of innovation networks in different situations from the perspective of cultural heterogeneity, which helps network members to use more effective governance mechanisms according to different cultural situations[14]. Based on the global-local perspective, Cao Xianzhong (2018) discussed the difference in innovation network efficiency with Shanghai high-tech industry as a case. The results show that the efficiency of Shanghai high-tech industry innovation network is affected by the combination of industrial characteristics and spatial distance[15].

2. Research Status of Innovation Network Structure

In the innovation network, the relationship between organization and organization can be expressed in a structured form. The actors in the relational network are called nodes, and the relationship between the nodes is symmetrical and asymmetrical, that is, The direction of object flow may be unidirectional or bidirectional. Different nodes are different roles in the network. Due to the interaction between network members, the location occupants of different nodes form a relatively stable role and status. If the relationship between nodes is repetitive, relatively fixed, and persistent, it is a strong relationship. If it is non-repetitive, non-fixed, and non-persistent, it is a weak relationship[16]. From the perspective of the constituent elements, Wei Jiang (2003) proposed that the components of the enterprise innovation network include suppliers, competitors, customers and the public sector[17]. Zhang weifeng and wan weiwu (2004) divided the enterprise innovation network into five types from loose to tight from the two aspects of enterprise participation and network control degree in the network[18]. From the perspective of linkage, Lundvall (1988) proposed the term connection, emphasizing the interrelationship and interaction between innovation elements[19]. Existing research divides the types of innovation networks into internal innovation networks and external innovation networks. In the interaction between internal and external networks, the internal innovation network is the core of enterprise innovation. The external innovation network mainly acts on innovation performance through the internal innovation network. The internal innovation network plays an important intermediary role. Meanwhile, internal innovation network also has a significant impact on external innovation network[20]. Wang Yanni (2012) further extends the connotation of the enterprise innovation network, and believes that the enterprise innovation network is a combination of internal innovation networks and external innovation networks[21].

The network structure refers to the relationship model exhibited by the overall network of the enterprise. The structural characteristics of the innovation network are reflected in the network scale and network density[22]. Wang Yanni (2012) believes that relationship strength is one of the most concerned feature variables to measure the impact of enterprise innovation networks on innovation performance[23]. Sheng Ya and Fan Dongliang deeply discussed the characterization of structural holes in the cluster innovation network. It is found that the more structural holes the network has, the more innovative resources such as information and knowledge can be obtained[24]. He (2016) analyzed the structural characteristics of the industry-university research innovation network from four aspects: network density, centrality, agglomeration coefficient and structural hole[25]. Wang Cong (2017) analyzed the structural characteristics of regional collaborative innovation networks from four aspects: network density, network center potential, network average distance and cohesion index[26]. Wang Lu (2018) used the network density, degree center potential, small world and

structural hole index to measure the joint patent data of 28 universities in Jiangsu Province, and accordingly proposed innovative activity strategies for the whole network and universities[27].

3. Research Status of Innovation Network Evolution

To build an efficient network, it is necessary to understand "how the network evolves and changes over time" (Nohria, 1998)[28]. Therefore, the focus of innovation network research on network evolution has strong theoretical and practical significance. In fact, the evolution of the innovation network itself and its co-evolution with technology research and development and industrial development are hot topics in the field of innovation research in recent years[29]. Liu Hongcheng and Tong Yunwei (2010) believe that the evolution of innovation networks can be expressed as the increase or decrease of the active subjects in the network, and can also be expressed as the change of network relationship, governance form, network structure and the network subject has not changed, but most of the time it is a mixture of the above[30]. Xu nana and xu yusen (2016) analyzed the specific realization path of reverse innovation of late-developing enterprises in different stages through the longitudinal case study of haier group, and pointed out that the cooperation between internal resources and external innovation network embedding is the key to reverse innovation upgrading of late-developing enterprises in the context of innovation networking[31]. Hu Haibo and Huang Tao (2016) take the two auto manufacturing enterprises of non-core enterprise Jiangling Motor and the core enterprise Chery Automobile in the global manufacturing network as the research object, and use the exploratory case study method to explore how the enterprise is in terms of structural characteristics and influencing factors. The operation of the innovation network, and then summed up the evolutionary structure model of the enterprise innovation network[32]. Chen Wenjie (2016) took the top 100 leading organizations in the global low-carbon automotive technology innovation patent application as the research object, and analyzed the characteristics and evolution path of the global low-carbon automotive technology cooperation innovation network[33]. Gao Xia and Chen Kaihua (2015) studied the dynamic mechanism and structural evolution characteristics of the industry-university-research cooperation innovation network in China's ICT field by means of complex network analysis methods[34]. Hu Xuhua (2017) compared the different life cycle as the entry point and compared the evolution mechanism of regional innovation network in China's electronic information industry[35]. Jiao Zhibo (2018) analyzed the evolution and characteristics of the collaborative innovation network of Heilongjiang equipment manufacturing industry based on patent data[36].

4. Summary

At present, scholars mainly study the structure, evolution and influencing factors of innovation networks. The research methods are mainly case analysis and social network analysis methods. The relationship between innovation networks and innovation performance is also a research hotspot. Future research can also consider the impact of innovation investment and R&D investment on innovation networks.

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Research on the relationship between collaborative knowledge innovation of supply chain and enterprise performance (No. GKYC201715).

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