

Research on Innovation Network based on Inter-enterprise Collaboration

Mengxin Dai

School of Management, Shanghai University, Shanghai, China

Abstract

In order to complete innovation and maximize profits, enterprises often seek partners to cooperate with other innovation entities (such as enterprises, schools, research institutes, government agencies, agencies, service agencies, etc.), that is, synergy. The innovation system or network system formed by the enterprise in the collaborative innovation activities and other entities relying on each other and interdependent, and interacting with each other is the collaborative innovation network. Firstly, the connotation of collaborative innovation network is defined. Secondly, its characteristics, components and attributes are analyzed. Finally, the research direction is proposed and proposed, which provides powerful theoretical support and decision-making basis for the benign development of collaborative innovation system.

Keywords

Enterprise, Synergy, Innovation network.

1. Introduction

With the acceleration of economic globalization and the increasing pressure of international competition, innovation has become an important means for enterprises to build their core competitiveness. Innovation subjects are becoming more and more dependent on complementary knowledge and external resources, so it is more and more urgent to carry out extensive exchanges and in-depth cooperation with other innovation subjects. Due to the scarcity of innovation resources, the high cost of innovation activities and the uncertainty of innovation results, enterprises cannot engage in innovation activities alone and need to seek partners for cooperative innovation[1]. Innovation is gradually transforming into a systematic and networked paradigm. It is difficult for individual innovation activities or even small-scale and single-level cooperative innovation to meet the needs of technological innovation. Collaborative innovation arises at the historic moment under this background[2].

Previous studies have studied collaborative innovation networks from the following aspects: Research on the dynamic mechanism of collaborative innovation based on certain theories; Zhang Zhe (2008) used diamond model, collective efficiency model and flexible specialization model to construct the dynamic mechanism model of industrial clusters to analyze the dynamic mechanism of collaborative innovation of enterprises in industrial clusters[3]. Research on the relationship between network evolution effectuation and micro node behavior characteristics. For example, Xie Xuemei et al. (2013) studied the mediating effect of knowledge absorption ability on network characteristics and innovation performance in collaborative innovation networks of enterprises[4]. As for the analysis of collaborative innovation motivation factors, Zhou Zheng et al. (2013) divided collaborative innovation motivation factors into external motivation and internal motivation, and believed that the driving force of industry-academy-research collaborative innovation is the result of the joint action of internal and external motivation factors[5]. For example, Shao Jingfeng et al. (2013) studied the internal and external forces of industry-University-Research collaborative innovation and the driving mechanism of

these forces for industry-university-Research collaborative innovation by using the multi-agent theory and particle swarm optimization (PSO), starting from the extraction of key forces for industry-university-Research collaborative innovation[6]. For example, Yan Mingyu (2014) discussed the collaborative innovation motivation mechanism led by science and technology business incubator based on the orderly flow of innovation costs and innovation resources[7]. About the influence factors of innovation network of collaborative research, such as Wei Yunfeng and RuanPing south (2018) from the individual layer, the relationship between the three dimensions and the network layer, using the structural equation model to validate the role of the relationship between influencing factors, it is concluded that the individual layer, the relationship between layer and network layer factors from different degree influence the realization of the synergy[8]. For example, Zhang Zhihua et al. (2019) took Internet of Things enterprises in strategic emerging industries as the research object to explore the mechanism and path of synergetic innovation network's influence on innovation performance [9]. For example, Song Jia and Lu Na (2019) analyzed the industry-level collaborative innovation model in the context of artificial intelligence[10].

It can be seen that scholars have gradually deepened their research on the model, influencing factors and driving mechanism of collaborative innovation, and made certain research achievements. They began to realize that the realization of collaborative innovation depends on the model construction and mechanism improvement of collaborative innovation network. So comb collaborative studies of innovation network of enterprise cooperative innovation between network connotation, characteristics, elements, attributes, study will be helpful to further understand the inner mechanism of the cooperative innovation, to fill that void in collaborative innovation theory research, more responsive to when funds innovation model from closed to open, from unilateral to pluralism, from linear trend of the development of the network, improve the efficiency of collaborative innovation, but also promoted the improvement of independent innovation ability in our country, and offer reference to solve the problem of innovation bottleneck.

2. Connotation of Collaborative Innovation Network

The concept of network originated in the 1960s and 1970s, and the concept of network and netting began to be popular in the 1980s and 1990s. Harland in the UK (1995) pointed out that the original concept of network is usually described as a structure of "network" connected by fiber lines, metal lines and other analogs, while the current network refers to the connection between behavioral subjects in different forms. Imain Baba (1989) first defined innovation network as: innovation network is a basic institutional arrangement to cope with systematic innovation. Zhao Minjie and Liu Songbo (2004) proposed that, based on information technology, it is composed of specialized joint assets, Shared process control and common collective purpose. Through the network connection of active nodes, the organic organization system can obtain some long-term competitive advantage. Network organizational innovation is completely open, without a clear boundary[11]. Xie Xuemei (2010) used the structural equation model to discuss such collaborative innovation networks as "enterprise-enterprise", "enterprise-intermediary", "enterprise research organization" and "enterprise-government"[12]. Cui Yonghua and Wang Dongjie (2011) proposed that, with the active support of the government, the innovation service system of people's livelihood science and technology should be established through the collaborative cooperation and joint participation of enterprises, universities, research institutes, intermediary organizations and other regional subjects of people's livelihood science and technology innovation[13]. He Yubing (2012) believes that with the in-depth development of industry-University-research cooperation activities, the "point-to-point" cooperation mode between enterprises and universities has

become outdated, and it is necessary to break through the previous linear mode of universities from research results to industrialization, and realize the parallel mode based on collaboration or even network mode[14]. System (2011) proposed that cooperative innovation is a complex organization, its key is formed with universities, enterprises and research institutions as the core elements of the government, financial institutions, intermediary organizations, innovation platform, multiple subject of nonprofit organization for auxiliary elements such as collaborative interactive network innovation model, through the knowledge creation and technology innovation subject resource integration, and further cooperation between non-linear utility system superposition[15].Dina liu changle and yan (2013) argue that synergy innovation network is refers to the innovation main body in order to improve the success rate, a growing reliance on complementary knowledge, cooperation with other subject, organizations tend to be more and more obvious, innovation is no longer a separate activities, but a multiple levels and multiple organizations, multiple stages and multiple innovation elements of dynamic complex network of activities as a whole[2].Chen Jindan and Huang Xiao (2015) believe that collaborative innovation will integrate synergy and innovation, and emphasize that through the organic coordination and non-linear interaction process of enterprise innovation elements, the overall innovation effect that cannot be achieved by a single innovation element can be generated[16].Yao Yanhong et al. (2018) hold that collaborative innovation network is an interdependent open innovation system formed through knowledge interaction and resource sharing between leading enterprises and upstream and downstream enterprises, customers, research institutions, intermediary institutions, governments and other related subjects [17].

This paper argues that the innovation system or network system formed by the interdependence, interdependence and interaction between enterprises and other subjects in collaborative innovation activities.Compared with the traditional industry-university-Research, the COLLABORATIVE innovation network has the characteristics of "deep collaboration". It is a complex system of correlation, interaction and collaboration among various elements, and an innovation ecosystem of self-gain cycle under the environment of complex collaborative network innovation [18]. Through the collaborative innovation network, enterprises can effectively acquire the required knowledge, technology, equipment, capital, information and social network and other resources, and generate synergies by forming the "new resources" of enterprises.

3. Features of Collaborative Innovation Network

Based on previous literature, this paper believes that the innovation network based on inter-enterprise collaboration has three characteristics: synergy, complexity and dynamics:

3.1. Cooperative

Synergy is a universal law in innovation system, especially in the innovation system based on enterprise synergy.Each innovation subject in the system influences each other, interacts with each other, and interacts with the environment to adapt, coevolves.If an innovation subject cannot adjust and change with the change of other innovation subjects and environment, it will be faced with the risk of being eliminated, and the stability and development of the whole system will also be affected.Co-evolution is based on the interaction and adaptation between innovation subjects, innovation subjects and the environment in the system, which reflects the integrity of the system development, helps to maintain the stability of the system, and shows the economic phenomenon that the overall force is greater than the sum of the parts.

3.2. Complexity

Complex system is an adaptive system composed of a large number of interacting units. Complexity is the behavior organization characteristic of complex system. Based on the

cooperative innovation between enterprises system as a kind of complex system, it not only in terms of individuals for a variety of innovation reflects the complexity, and in the interaction between innovation subjects also caused the complexity of innovation system, and the innovation main body and the external environment of interaction and influence of innovation system becomes more complex.

3.3. Dynamic

Based on enterprise synergy innovation network is not steady constant, but with the continuous development of enterprise and development, the participation of enterprise innovation network node number, number of nodes in the relationship between the complex, as a complicated dynamic system and innovation system of internal main elements constantly absorbing external resources, to provide information for its own development, resources and technology input, but also to the external output related products, information and services. The innovation network of enterprises also interacts with the external environment, influences and interacts with each other, making the innovation network develop continuously.

4. Components of Collaborative Innovation Network

The collaborative innovation network consists of two parts: the innovation subject and the innovation environment. Innovation subjects mainly include enterprises, universities, research institutions, intermediary institutions and end users, etc. Innovation environment includes market environment, policy environment, financial environment, technological environment, cultural environment, infrastructure environment, etc. the complex collaborative innovation system is formed by the interaction between subjects and elements.

The main factors of innovation are mainly divided into the following categories: enterprises, universities, research institutions, intermediary institutions and end users. In an innovation system based on inter-enterprise collaboration, the enterprise is the main force for innovation in the system. The enterprise and other cooperative enterprises jointly research and develop, and convert the research and development results into final products to sell to users, so as to obtain innovation benefits. Universities and research institutions, with abundant human resources and strong scientific research capacity, are indispensable subjects in the innovation ecosystem of high-tech enterprises. They rely on the information and resources provided by the innovation ecosystem to carry out research and development, and gain returns by selling the research and development results. Intermediary agencies are powerful assistants in communication between enterprises. Although they do not have research and development ability, they can better help enterprises to carry out cooperation and communication in the research and development process by relying on their own understanding of various enterprises in the market. The end user is the deepest understanding of the use effect of product groups, they can decide the products in the market, to the end user into the innovation of ecological system, rely on users understanding of the products, get the user the nature of the product demand, can make more adaptable to market research and development, more easily in the market, at the same time also can rely on end user large quantity basis, improve the system overall research and development capabilities.

Innovation environment elements are various specific environments in which the innovation ecosystem is located. These environments constantly change and constantly affect the development of the enterprise innovation ecosystem, including market environment, policy environment, financial environment, technological environment, cultural environment, infrastructure environment, etc. A good market environment is the guarantee that innovative products can obtain profits. If the technical environment is not up to standard, the research and development process will be hindered, or the research and development results cannot be converted into products to obtain profits; Through policy support, the government can create

a good environment for the development of innovation system. The cultural environment reflects the level of pre-regional education, and the fine cultural environment can cultivate excellent innovative talents. The financial environment determines whether innovation can get financial investment. The infrastructure environment such as the level of network development is the guarantee for the collaborative communication of the system.

5. Attributes of Collaborative Innovation Network

In this paper, the following four indicators are used to describe the attributes of collaborative innovation networks:

5.1. Network Size

Network size is represented by the number of nodes in the network[19], the node of the innovation network can be not only each innovation subject in the network, but also the things and behaviors with value and function produced by the communication between each subject. This paper defines it as the number of all innovation species contained in the innovation network. Therefore, the larger the innovation network is, the more complex the system structure is and the more heterogeneous resources it contains.

5.2. Network Density

Network density is the degree of cooperative relationship between nodes, which has obvious influence on the behavior and effect of cooperative innovation of enterprises in the network. In a high-density network, each node can contact other nodes more directly, and information and resources flow and share faster in the network[20]. The more nodes, the greater the density, the more opportunities for innovation, the stronger the innovation ability. Wang Haihua et al. (2019) believe that high network density indicates high accessibility, good trust relationship between regions, faster and more effective information flow and resource sharing, which is conducive to the continuous establishment of collaborative innovation relationship between regions and the improvement of collaborative innovation performance among nodes[21].

5.3. Network Centrality

In this paper, it is defined as the percentage of all shortest paths in the COLLABORATIVE innovation network containing innovation population I, which is used to indicate the extent to which an innovation population is located in the "middle" of other enterprise populations in the system. The more the node is in the center of the network, the more important it is in obtaining innovative information, controlling information channels and striving for cooperation opportunities[22]. Therefore, the higher the degree of intermediary center is, the more important this population plays as a medium of knowledge and resource dissemination in the open innovation ecological network. The degree of mediation centrality measures the mediation role played by the node in connecting other nodes in the network, that is, the possibility of the shortest path between other nodes passing through the node.

5.4. Structure Holes

Structural holes refer to connecting disconnected nodes so that new information and resources can be acquired in a timely manner and knowledge can be searched [23]. Structural holes are bridged with multiple nodes through holes on both sides. Structural holes represent the power of nodes in the network by the relational model of nodes. In decision-making, the area occupying the structure hole has the right to control information and resources, and the area located in the structure hole can effectively grasp and control the process of knowledge flow and information sharing that produce benefits. It plays an important role in the cooperation and development of innovative main business activities in the region, assisting and promoting the transformation of scientific research achievements, and reducing benefit losses caused by

information asymmetry[24]. The existence of structural holes influences the movement of knowledge flow and information exchange and sharing, and ACTS as a communication bridge for innovation subjects in the region [25] Can improve the efficiency of the entire innovation network.

6. Conclusion

Found in the analysis of the research in recent years, the hot spot in recent years, the field focuses on the study of the collaborative innovation model and mechanism, for now, to construct the essences of collaborative innovation system has become research, how to implement the collaborative innovation is not only affect the enterprise itself, also affect the supply chain and supply chain upstream and downstream enterprises, in the whole enterprise as the core of the innovation system, the collaborative innovation plays an important role.

Based on previous research literature, this paper defines the concept of collaborative innovation network, and think in collaborative innovation network is the enterprise in collaborative innovation activities with other main body depend on each other, each other, interact each other to form the innovation of the system or network system, and a collaborative, complexity and dynamic three characteristics of enterprise cooperative innovation between network elements including innovation main body and the environment of two parts, and points out that enterprise synergy innovation network between five attributes: network scale, network density, network mediation center hole and structure.

Although many scholars have defined the development context and concept source of the collaborative innovation network, the various characteristics of the collaborative innovation network determine its rich and varied connotation. The academic circle still has no authoritative interpretation of this, so the concept connotation of the collaborative innovation network needs to be further discussed.

In addition, the existing research literature on network performance mainly focuses on the establishment of innovation performance evaluation index system, evaluation of the impact of network characteristics on innovation performance and its influencing mechanism. However, most researches focus on the influence of certain characteristics of THE COLLABORATIVE innovation network on innovation performance, and the influence mechanism and intermediary variables are relatively weak. Therefore, comprehensive description of the characteristics of the collaborative innovation network and comprehensive evaluation index system should be the key direction of future researches.

At present, collaborative innovation research institutions are mostly concentrated in the economically developed southern regions, which is also related to the high and new technology industries and technology enterprises are mostly concentrated in the economically developed regions. The enterprises selected in the empirical research are also mostly concentrated in the Beijing-Tianjin-Hebei region and the pan-Yangtze River Delta region, and there are few researches on collaborative innovation in other regions. Therefore, it is necessary to strengthen relevant researches on collaborative innovation in regions with relatively backward economic conditions, insignificant or poor innovation effects. In general, research on collaborative innovation is still insufficient, and further research on collaborative innovation needs to be further strengthened. There is also a need to strengthen communication and cooperation between authors and institutions in future research.

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