

## Research on the Construction and Performance Analysis of Collaborative Innovation Network of the Industry-University-Research-Finance

Man Zhang

Business School, Northwest University of Political Science and Law, Xi'an 710122, China

**Keywords:** Scientific and technological innovation; Collaborative innovation network of Industry-University-Research-Finance(IURF); Innovation performance

**Abstract:** Under the background of open innovation, an important issue of the country to promote the development of technology innovation is construction and performance evaluation of the collaborative innovation network for the Industry-University-Research-Finance(IURF). This paper expanded the scope of innovation subjects of the traditional collaborative innovation network, and constructed a collaborative innovation network, including of the main innovation subjects, such as enterprises, universities, research institutions and financial institutions. Combined with the typical strategic emerging industry cluster innovation network, this paper analyzes the case, and gives the countermeasures and suggestions to improve the performance of the network, which provides a reference for the development of the network.

In the open innovation environment, with the development of the integration of science, technology and economy, collaborative innovation network of IURF has become the first choice to realize the knowledge creation, diffusion and industrialization. It is a cross organizational knowledge exchange and knowledge transfer network, which takes the innovation subjects such as enterprises, universities, scientific research institutions, as well as the exogenous influencing factors such as science and technology service institutions, governments, financial investment institutions as a whole, and takes the realization of technological innovation and the transformation of scientific and technological achievements as the main purpose. At present, a large number of strategic emerging industry cluster innovation networks have sprung up in China, such as Zhongguancun, which has the title of "the world's first innovation cluster in the future"; Shanghai Zizhu emerging industry technology research institute, which was founded in Shanghai in 2010; and Xi'an Yanliang National Aviation High Technology Industry base. They are all the collaborative innovation network of IURF, they play an irreplaceable role in the process of scientific and technological innovation and transformation of scientific and technological achievements. In the process of science and technology innovation, the role of technology finance is prominent. The Ministry of science and technology and governments at all levels had realized the importance of the coordinated development of science finance and science innovation. In recent years, the government, together with the people's Bank of China, China Banking Regulatory Commission, the Ministry of Finance and other departments, has issued a number of financial policy documents focusing on promoting scientific and technological innovation. Under the guidance of the government, many new financial service institutions have been established in the strategic emerging industry cluster park. Therefore, it is a necessary process for technological innovation and development to transform financial institutions from exogenous influencing factors in collaborative innovation network of IURF into an important innovation subject like enterprises, universities and scientific research institutions to form the network, strengthen the integration innovation of industries, universities and research funds, and promote economic and social development.

According to the report of "Statistical analysis on the national main science and technology plan of transformation and application of achievements in 2014" released by the Innovation and Development Department of the Ministry of Science and Technology on January 14, 2016, 9302 subjects were tracked and investigated throughout the year, of which 4906 subjects failed to be transformed and applied, accounting for 52.7% of the total subjects. Although the number of

transformation of various subjects has increased by 2 to 3 percentage points on average compared with the previous year, the transformation rate of scientific and technological achievements still has a lot of room for improvement. According to the data, among the achievements that had not yet been transformed, 47.8% (2012), 49.2% (2013), 43.1% (2014) of the total achievements had not been transformed due to the funds needed for transformation and application, industrial supporting technology, relevant technical personnel and cooperative units. Among them, 31.1% (2012), 30.1% (2013) and 27.1% (2014) of the total untranslated achievements were not fully funded. The reason is that technology finance has not kept up with the development speed of science and technology innovation, the integration of industries, universities and research funds is not smooth, and the organization mode of IUR has not been clarified. This paper will explore and analyze the reasons for the low conversion rate of scientific and technological achievements, in order to provide more valuable theoretical and practical reference for scientific and technological innovation management.

## 1. Introduction

Collaborative innovation is a new paradigm of scientific and technological innovation and a high-level form of Industry-University-Research cooperation. It is a large-span integrated innovation organization mode which is carried out by enterprises, governments, universities, scientific research institutions, intermediary institutions, financial institutions and other innovation subjects with the goal of achieving major scientific and technological innovation and the core of knowledge appreciation.<sup>[1]</sup>

IUR began with the innovation theory put forward by Schumpeter, and then many scholars followed, and the connotation of innovation research continued to improve. Until the 1970s, American scholars Nelson and Winter created the evolutionary economic theory of innovation, which led to a large number of researches on the innovation process from the perspective of system as a whole. In the 1980s, with the rise of emerging industries, it had become the focus of scholars to strengthen the combination of industries, universities and research institutions, and promote the transformation rate of scientific and technological achievements. In 1991, Freeman pointed out that innovation network is an innovation cooperation relationship between enterprises, and proposed the concept of innovation network.<sup>[2]</sup> Since the 21st century, the related concepts of collaborative innovation combination of industries, universities and research institutions had extended to innovation of IUR, networking of IUR, industry cluster innovation network, cluster innovation network of IUR etc., the research heat had increased unabated, and the research angle and method were more diversified.<sup>[3]</sup>

Most of the foreign scholars had used empirical research methods for the collaborative innovation network of IUR. Graf and Henning (2009) found that universities and research institutions occupy an important position in the regional patent cooperation network. The higher the density of innovation network is, the more universities and public research institutions in the network. It can be seen that the role of industry and university institutions in the innovation network is very important.<sup>[4]</sup> Petruzzelli(2011) investigated the patent cooperation networks of 33 universities and enterprises in 12 European countries, and discussed the influence of technology relevance and geographical distance on the formation of patent cooperation network of universities.<sup>[5]</sup> C. Wang and S. Rodan (2014) proposed that the mechanism of innovation network includes not only the mutual coupling of knowledge elements in knowledge network, but also the social network in which innovators learn and cooperate with each other.<sup>[6]</sup>

Domestic scholars had also been committed to this aspect of research. Y.Qi (2015) used social network analysis method to draw a conclusion that there is a large space to improve the relationship between the main bodies of collaborative innovation of Jiangsu IUR and put forward countermeasures and suggestions to promote collaborative innovation of IUR.<sup>[7]</sup> Y. Zhang (2013, 2015) based on the characteristics of scale-free network, considering the exit mechanism, robustness and weight change of nodes, constructed the evolution algorithm of cooperation network of IUR.<sup>[8]</sup> <sup>[9]</sup>At the same time, scholars also found that, in addition to universities, scientific research institutions, enterprises and other innovation subjects in the network of IUR, financial service institutions are very important to promote scientific and technological innovation and enhance national innovation

capacity. J. B. Ang (2010) based on the time series data of South Korea, through the empirical research on the role of financial sector and R&D activities in the innovation economy, it is concluded that financial liberalization is strongly related to national scientific and technological innovation.<sup>[10]</sup> J. Yin (2015) pointed out that there was a lack of funds in the current cooperation of IUR, and the demand for technology finance is growing day by day. They had built a collaborative development mode of IUR and technology finance.<sup>[11]</sup> Y. Liu (2017) designed the social relationship network, coordination network and cooperation network of IUR that interact with each other and interact with each other by using the super network method, constructed the super network equilibrium model of IUR collaborative innovation based on the financial capital and intermediary role, and gave the framework and path of realizing the super network equilibrium of coordination innovation of IURF.<sup>[12]</sup> The research on IUR has gradually transferred to the research on the collaborative innovation of IURF.

Looking at a large number of studies by scholars, the collaborative innovation network of IURF has become a new mode of scientific and technological innovation, but the research is still in the stage of theoretical exploration on the whole. Most of the research is mainly concentrated on the concept, structure, type, governance mechanism, development mode, etc. of the traditional collaborative innovation network of IURF.

## 2. Construction of IURF

The beneficial experience of the US, UK and other developed countries in the construction of collaborative innovation shows: only the developed financial capital market can guarantee the active technological innovation and the vigorous emerging industries. Based on the core innovation subject of enterprise, universities and scientific research institutions in IUR, IURF brings in another important core "financial institution", which makes the deep integration of IUR, realized the effective allocation of all kinds of innovation resources and the knowledge flow among innovation subjects, and forms "Industry Chain-Science and Technology Innovation Chain-Finance Capital chain", it is a perfect cross-border integration organization mode.

**The relationships between the main bodies of IURF.** IURF is an open and complex system. There are complex nonlinear interactions among all subjects in the system. The innovation subjects are closely connected to form a sub network, and there are certain connections among the sub networks, which is a typical multi complex network, including knowledge flow or capital flow.

The governments play an absolute leading role in the network. In order to encourage scientific and technological innovation, support measures are provided for enterprises, universities and other innovative subjects, such as project funding, innovation subsidies, etc.; financial capital is guided to flow to the field of scientific and technological innovation through the establishment of policy guarantee institutions, venture capital guidance funds, etc.; infrastructure construction, environmental culture construction and institutional environment construction are improved.

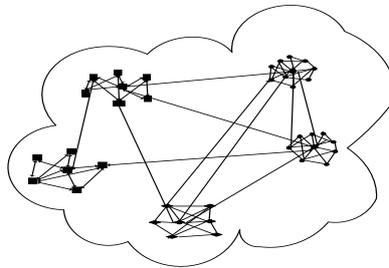
The most fundamental role of science and technology intermediaries in the network is information communication. The obvious information asymmetry between innovation subjects is the obstacle and barrier of knowledge flow and capital flow. Science and technology intermediary institutions optimize resource allocation for innovation subjects and transfer information reasonably.

The core innovation subjects in IURF include enterprises, universities, research institutes and financial institutions. Under the guidance of the government and with the help of scientific and technological intermediary agencies, the core innovation subjects should cooperate with each other to the greatest extent, make knowledge exchange and capital exchange steady and sustainable, and achieve the maximum benefit. Enterprises, universities and research institutions need the funds support from financial institutions to carry out scientific and technological innovation. Financial institutions need to obtain corresponding profits for their investment. Although there will be cooperation between the two sides due to common interests, there will also be competition in enterprise management and control rights. Enterprises, universities and research institutions will jointly break through key technologies and achieve cooperation in the transformation of scientific and technological achievements, but there will also be competition for intellectual property rights and benefit distribution.

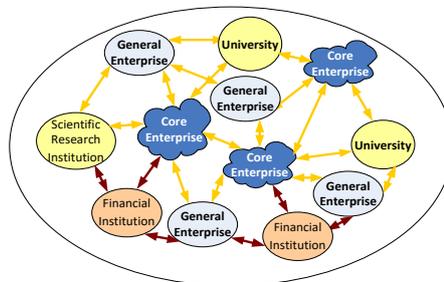
**Construction of IURF.** There are complex nonlinear effects among the core innovation subjects. Regarding the innovation subject as a point and the cooperation relationship between the innovation subjects as a line, IURF is formed. IURF is a network composed of several small cluster innovation networks (sub networks). These sub networks cooperate with each other and exchange knowledge and capital with each other to form a large network. The sub network is an innovation network composed of universities, research institutions, financial institutions, core enterprises and general enterprises. Because of the cooperation, the innovation networks are closely related to each other. The system thus forms an interdependent relationship and constitutes an interdependent network. As shown in Fig. 1., the node is each innovation subject and the connection is the cooperation relationship between innovation subjects.

The internal structure, knowledge and capital flow of the sub network are shown in Fig. 2.

The essence of IURF is a two-layer network. Closely connected and highly dependent innovation subjects form a sub network. These networks have no boundary. Innovation subjects within the sub network and innovation subjects outside the sub network also have knowledge and capital exchange, share resources, and form an open innovation mode. Using the theory of double-layer network to study IURF provides a new idea for performance analysis, mining the factors that affect the barriers of knowledge exchange and the stability of the whole network.



**Fig. 1.** Schematic diagram of IURF



**Fig. 2.** Internal cooperation diagram of IURF (Yellow arrow represents knowledge flow; Red arrow represents capital flow.)

### 3. Performance Analysis of IURF

National High-tech Zone has become a banner of independent innovation with Chinese characteristics, playing a leading role in innovation driven development, transformation and upgrading, and is the most important strategic force to promote the development of "Mass entrepreneurship and innovation" and high-tech industries in China. Xi'an high-tech Industrial Development Zone (Xi'an High-tech Zone) is the first batch of national high-tech zones approved by the State Council in March 1991. After more than 20 years of development, the main economic indicators have grown rapidly. Its comprehensive indicators are in the forefront of national high-tech zones in China. It has become the most powerful economic growth and opening-up window of Xi'an city and Shaanxi Province, and is a new development strategy important base for industrial development, it has been approved to build a national independent innovation demonstration zone. It is trying its best to strengthen the cultivation and development of IURF. The organization mode of the

whole Science Park is a typical strategic emerging industry innovation cluster network.

Yanliang National Aviation high-tech industrial base (Aviation Base) is the first domestic aviation high-tech industrial base approved by the National Development and Reform Commission in August 2004. After more than 10 years of development, Aviation Base has formed an aviation industry cluster of outstanding competitive advantages, with complete machine manufacturing as the backbone, and with the aeroengine, airborne system, aviation big parts, aviation new materials as the branches, aviation parts processing, aviation refitting and maintenance, flight training, aviation tourism expo as the supporting. It is the most influential aviation high-tech industry park in China, a typical network of strategic emerging industry innovation clusters.

Through the field investigation and comparative analysis of the above Science Parks, it can be seen that: in the IURF, the policy guidance and financial support of the park conducive to collaborative innovation have a great impact on the performance of the whole park, and the strong guidance of the government and the deep participation of financial institutions are crucial to the development of the IURF. Compared with Yanliang Aviation Base, Xi'an High-tech Zone has better performance in government guidance and participation of financial institutions, especially in cooperation. Shaanxi Province has not really formed a multiple and stable IURF, and the whole development is still in its infancy. Although the cadres above the middle level of the management committee know the importance of collaborative innovation under the call of the government, they do not really understand the benefits and risks brought by the cooperation, coordination, management, internal mechanism and cooperation among the innovation subjects, not to mention the improvement and implementation of various policies and measures of collaborative innovation, which is also very important for the development of the IURF. It is in urgent need of more support of relevant research results and training of relevant personnel suitable for the development of the Science Park.

#### **4. Conclusions**

Based on the above research, this paper proposes the following policy recommendations to improve the performance of IURF:

(1) Improve the policy support system and science and technology intermediary system of IURF. Institutional innovation is a powerful guarantee for scientific and technological innovation, and the bridge role of scientific and technological intermediary is an accelerator for collaborative innovation. Well policy environment and perfect science and technology intermediary system lay the foundation for improving the performance of collaborative innovation network.

(2) Establish relevant talents training mechanism. Talents are the first factor to promote the development of collaborative innovation network of IURF. The cultivation of industrial innovative talents is as important as that of management talents in Science Park. It is a very effective way to strengthen the joint cultivation of high-level innovative talents and vocational and technical training relying on universities and enterprises.

(3) Promote the close combination of technology and finance, and maximize the role of financial institutions in the network. There is an urgent need to establish and improve a multi-level and diversified venture capital and financing system covering R&D, incubation, industrialization, etc. in the Science Park, and strengthen the interaction among the government, financial institutions and enterprises, so as to build a venture capital system led by the government and supported by financial institutions. The multi-faceted and deep participation of financial institutions will rapidly improve the performance of the IURF.

(4) Create an open IURF. In the Science Park, we should cultivate innovation and entrepreneurship culture, strengthen intellectual property management, improve benefit distribution system, protect the enthusiasm of innovation subjects, and form an open, harmonious, stable and well functioning high-performance innovation network.

#### **Acknowledgements**

This work was supported by the project of Shaanxi Social Sciences Association, «Research on

the operation mechanism of collaborative innovation network of IURF in Shaanxi Province»( 2019C168).

## References

- [1]. J.Chen, Y. J.Yang:Theoretical basis and content for collaborative innovation[J]. Studies in Science of Science, Vol. 30 (2012) No.2, p.161-164.(In Chinese)
- [2]. C.Freeman: Networks of innovators: A synthesis of research issues[J]. Research Policy,Vol. 20 (1991), p.499-514.
- [3]. Y. B.He: The theoretical model of I-U-R collaborative innovation[J]. Studies in Science of Science, Vol. 30 (2012) No.2, p.165-174.(In Chinese)
- [4]. H.Graf,T. Henning: Public Research in Regional Networks of Innovators: A Comparative Study of Four East-German Regions[J]. Regional Studies, Vol. 43 (2009) No.10, p.1349-1368.
- [5]. A. M.Petruzzelli:The impact of technological relatedness, priorities, and geographical distance on university–industry collaborations: A joint-patent analysis[J]. Technovation,Vol. 31 (2011) No.7, p.309-319.
- [6]. C. Wang,SRodan andM.Fruin: Knowledge networks, collaboration networks, and exploratory innovation[J]. Academy of Management Journal,Vol. 57 (2014) No.2, p.484-514.
- [7]. Y. Qi, J. Wang: Industry-University-Research Institute CollaborativeInnovation Networks Based on Social Network Analysis[J]. Forum on Science and Technology in China, Vol. 11 (2015), p.11-17. (In Chinese)
- [8]. Y.Zhang, L.R.Jian: University-industry Cooperation NetworkModel Based on Scale-free Network [J]. Systems Engineering, Vol. 5 (2013) No.2, p.54-59. (In Chinese)
- [9]. Y.Zhang, L.R.Jian and Y. S.Zhang:University-industry Cooperation Network Evaluation Based on Weighted Scale-free Network [J]. Systems Engineering, Vol. 1 (2015), p.68-73. (In Chinese)
- [10]. J. B.Ang: Research, Technological Change and Financial Liberalization in South Korea[J], Journal of Macroeconomics, Vol. 32 (2010) No.1, p.457-468.
- [11]. J.Yin, F.Li:The Collaborative Development Mode of Industry-University-Research and TechnologyFinance by Government Leading[J]. Chinese University Science & Technology, Vol. 03 (2015), p.26-27. (In Chinese)
- [12]. Y.Liu:Cooperative Innovation for I-U-R Based on Super-network Equilibrium Model and Its Realization Route[J]. Forum on Science and Technology in China, Vol. 01 (2017), p.19-25. (In Chinese)
- [13]. J. Baum, A. Shiplov andT.Rowley: Where do small worlds come from? [J]. Industrial and Corporate Change,Vol. 12 (2003), p.697-725.
- [14]. R. T. Sparrowe, R. C. Liden and S. J.Wayne. Social Networksand the Performanceof IndividualsandGroups[J]. Academy of Management Journal,Vol. 44 (2001) No.2, p.316-325.
- [15]. C. I. Andrew, W. K Eric: Social Capital, Networks, and Knowledge Transfer[J]. The Academy of Management Review, Vol. 30 (2005) No.1, p.146-165.
- [16]. M. J. Nieto, L.Santamaría: The Importance of Diverse Collaborative Networks for the Novelty of Product Innovation[J]. Technovation, Vol. 27 (2007) No.6, p.367-377.
- [17]. K. H.Tsai, J. C.Wang: External technology sourcing and innovation performance in LMT sectors: An analysis based on the Taiwanese Technological Innovation Survey[J]. Research Policy, Vol. 38 (2009) No.3, p.518-526.
- [18]. L. J.Xia, F. J.Xie and H.H.Wang: The impact of institutional proximity and technological

- proximity on industry - university collaborative innovation performance: An analysis of joint patent data[J]. *Studies in Science of Science*, Vol. 35 (2017) No.5, p.782-791. (In Chinese)
- [19]. G.W.Hou, H. F.Xue: Cluster network relationship knowledge acquisition and collaborative innovation performance [J]. *Science Research Management*, Vol. 38 (2017) No.4, p.1-9. (In Chinese)
- [20]. Y.Q.Lu, Y. P. Ye: Impact of network routines on the innovation performance in industry-university-institute innovation[J]. *Science Research Management*, Vol. 38 (2017) No.3, p.11-17. (In Chinese)
- [21]. Y.B.He, Y. C.Zhang: Research on Coupling of Network Types and the Collaboration Modes of Industry-University-Research Institution Collaborative Innovation [J]. *Science of Science and Management of S. & T.*, Vol. 2 (2015), p.62-69. (In Chinese)
- [22]. X. Q.He: Research on the Regional Innovation Mechanism from the Perspective of Innovation Network Evolution—Taking High-tech and Low-medium-tech Industries as Examples [J]. *R&D Management*, Vol. 29 (2017) No.1, p.22-31. (In Chinese)
- [23]. T. L. Saaty: How to Make a Decision: The Analytic Hierarchy Process[J]. *European Journal of Operational Research*, Vol. 48 (1990) No.1, p.9-26.