Research on Industry－University－Institute Cooperation Innovation——Take High-end Equipment Manufacturing Industry in Shanghai, China as an Example*

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Abstract

As economic growth shift and the boundary of business cooperative innovation expand, industry－university－institute cooperation has become increasingly important for high-tech industry to adapt to more dynamic and flexible network which can help break through the innovation barrier and get heterogeneous resources. The present study aims to explore the structure of cooperative innovation network applying social network analysis, based on a sample of 218 organizations of strategic emerging in Shanghai, China include corporations, universities and institutes. It measures interaction relationship from the view of structural equivalence, combined with the multidimensional scaling method to describe the structure and characteristics of the whole network and transform cooperative innovation relations to the location colleges and universities, research institutes have greatest power of resource allocation in industry-university-institute cooperation innovation network. The results show The research results show differences in the struct (i)the whole net appears as decentralized and different types of organization distribution gathered at different levels at the space spatial map.(ii) Colleges and universities, research institutes have greatest power of resource allocation in industry-university-institute cooperation innovation network,

Keywords: Industry-university-institute cooperation, cooperation innovation, social network analysis, High-end equipment manufacturing industry

1. Introduction

With knowledge innovation is increasingly networked and enhancement of economic development reliance on innovation, there appears an urgent appeal for integrating decentralized and diversity resources effectively, particularly in the field of multiple institution and the cross application of the knowledge in different disciplinary, to fully realize the economic cooperation within the industry, and then promote industry sustainable development.

The technical innovation is regarded as a linear process driven by technology in the early innovation model while it emphasizes the integration of the system and the expansion of the network in current study. It means regional technology innovation pays more attention to cooperation and collaboration between different innovation organizations[i].A necessary response to this new challenge is taking industry－university－institute cooperation as the basic pattern of regional innovation system so that it could help promote industrial upgrading and regional competitiveness.

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Generally, industry－university－institute Cooperation Mainly identified in universities, research centers, and business companies who commit resources according respective advantages activities and go by benefit sharing, risk sharing and complementary advantages during innovation[ii].

The Essence of industry-university-institute cooperation Innovation is the connection between partners through the network, actually a kind of web-based collaborative innovation, which can bring about knowledge transfer and recreate[iii]. In other word, Cooperative innovation network is the collection of interrelation between institutions, include formal and informal relations, also the relations are based on the network structure and have certain embedability[iv]. There is no doubt that the relevance and the structure is important, as a result, we should pay more attention to inter-organization cooperation network within plural subjects as well as its influence on innovation. Social network analysis provides a new perspective and method for industry-university-institute cooperation innovation research.

Drawn from previous literature, we divide research of cooperative innovation based on social network analysis into two categories: One is based on the relationship between main bodies, concerns relation strength of the network and the impact of communication frequency on cooperative innovation, the other focus on multi-dimensional network structure, pays attention to the influence of network location, density and heterogeneity.

Isabel Salavisa, Cristina Sousa and Margarida Fontes applying social network analysis find that the formal access to complementary assets reflects distinct dynamics of the environment where firms pursue their activities, while the informal access to knowledge is associated with differences in knowledge bases[v]. Wang xiaoning concludes attributes of network, include density, strength, centrality and reciprocity, have significant positive effects on enhancing innovation capacity[vi] .

Similarly, extant research tends to address, in cooperative innovation networks of industry-university-research institution, centrality and structural hole promoted the innovation output of network output and centrality played a negative role in promoting the innovation output. Centrality always found in the cooperative innovation network and some institutions take central place in the network[vii].Most literature indicates the importance of the network for transmission of dominant and tacit knowledge in the innovation process, but more research is needed to discover the structure characteristic of network composed by different institutional structures and the body in multiple areas.

The paper is organized as follows. We start by identifying characteristics which seem to matter for the development of collaborative innovation like network density and central potential. Then we discuss how to measure the relation between the main collaborative innovators by the structural equivalence and convert the cooperation to the location of the structural equivalence using multidimensional scaling method.

Finally, we conduct an empirical analysis on the composition and structures of the networks built by firms, universities and institutes, and describe the overall network model. It will help combine the participants, "macro" structure and “micro" network together into an entire innovation system so that it provides a new perspective to explain the network structure within and across sectors.

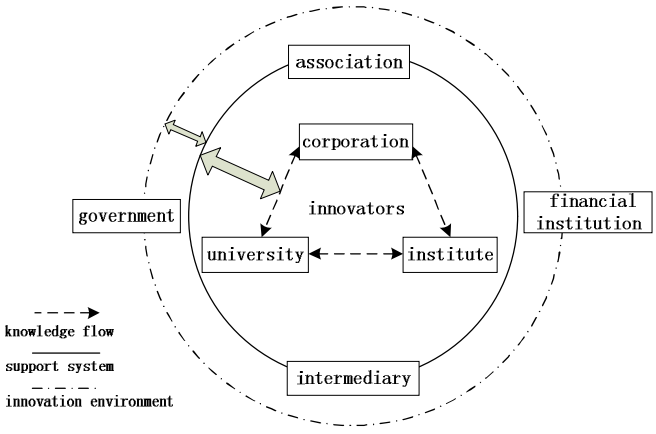

Fig.1. Cooperative Innovation Network

2. The Establishment of Cooperative Innovation Network

Cooperative Innovation network mainly consists of three main types with their formal and informal relationships between these main components: The first is the creative organization, including enterprise, universities and research institutions, who are not only the source of knowledge and technology innovation but also the beneficiaries of innovative achievements. It is contacts and cooperation between these bodies that push the production and dissemination of knowledge. The second category is the main foundation structures, such as the intermediary organizations and trade associations who play a major supporting role to regional innovation .The last one is innovation environment, for instance, local government s and financial institutions and so on[viii].

We choose the core part of cooperative innovation network and conduct empirical research in Shanghai of China with the aid of nuclear power office of Shanghai, aviation association of Shanghai, urban rail transportation association of China, shipbuilding industry association of Shanghai, so we get the list of organizations like companies and research institutes, and then select science and engineering undergraduate college from 63 universities in Shanghai. The collected cooperative innovation organization list of Shanghai includes 164 enterprises, 38 research institutes, 16 universities, 218 in total.

Since there is no statistical data of cooperative innovation, patent data, as a measuring for innovative cooperation or knowledge transfer between organizations, is in the majority of current study. This kind of practice is more convenient in terms of the collection and analysis of data, and is conducive to further quantitative research. Take the patent cooperation as the network connection, data gathered from the State Intellectual Property Office of the P.R.C, the equipment manufacturing industry sub-sites in the patent retrieval and service system. Take pairwise combination of 218 institutions as "patent applicant" field to retrieve, such as " (patent application) = (Shanghai industrial automation instrument research institute) “with "(patent application) = (Shanghai Jiaotong University)", meanwhile "(province code) = (Shanghai or 31) ". Finally, we input the data into Ucinet software, using netdraw software to map the cooperative innovation network.

Table 1: High-end equipment manufacturing industry cooperation in various fields

Field	Total	Independent patent organization	Independent patent organization /total organization (%)	No patent organization	No patent organization/total organization (%)	Cooperation patent organization	Cooperation patent organization/total organization (%)
Nuclear power(equipment manufacturing)	43	18	41.9%	2	4.7%	23	53.5%
Marine engineering	42	16	38.1%	4	9.5%	22	52.4%
Rail transportation	42	17	40.5%	4	9.5%	21	50.0%
Intelligent	61	24	39.3%	7	11.5%	30	49.2%
Satellite	44	19	43.2%	8	18.2%	17	38.6%
Aviation	36	20	55.6%	5	13.9%	11	30.6%

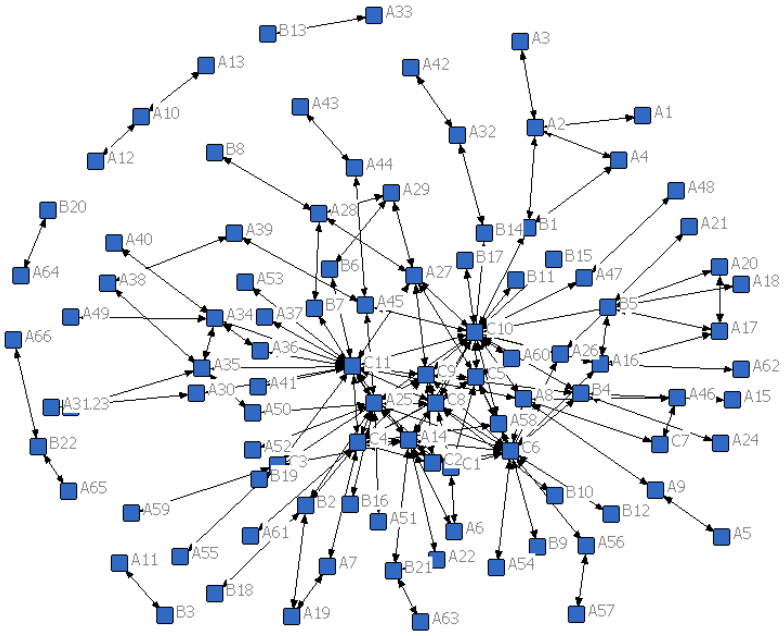

Fig.2. Cooperative innovation network of Shanghai high-end equipment manufacturing industry－university－institute

Note:A1—A63 represent 63 high-end equipment manufacturing corporations in Shanghai, B1—B22 represent 22 institutes in this area, and C1—C11 represent 11 universities. All the names are shown in Table.2

In industry－university－institute cooperation innovation network of the high-end equipment manufacturing industry,101 organizations have been innovative cooperation with other institutions in its network, account for 46.3% of 218 organizations including universities, research institutes and the enterprises, while 87 have been only independent patent, it means they have no cooperation with other institutions in the network, accounting for 39.9%; The remaining 30 have no patent for invention, account for 13.8%.

Then, we classify 218 organizations according to the six subordinate fields in Table1, it can be seen that the nuclear power equipment manufacturing industry and Marine engineering equipment manufacturing industry have a higher percentage of innovation cooperation within the network, while aviation equipment manufacturing industry and satellite equipment manufacturing industry have a lower proportion.

Table. 2 Participants in industry－university－institute cooperative innovation network of Shanghai high-end equipment manufacturing industry

field	corporation	institute	university
Marine engineering equipment manufacturing	shanghai dredging equipment industry company A1 CCCC shanghai dredging Co.,Ltd A2 … The Chinese design and research institute of engineering Co.,Ltd A13	China state shipbuilding corporation institute, 708 B1… shipbuilding technology research institute B3	Shanghai institute of technology C1 Shanghai university of electric power C2 Shanghai Dianji university C3 University of Shanghai for science and technology C4 Donghua university C5 Shanghai university C6 Shanghai maritime university C7 East china university of science and technology C8 Fudan university C9 Shanghai Jiao tong university C10 Tongji university C11
Nuclear power equipment manufacturing	shanghai electric A14 … Baosteel A25	shanghai nuclear engineering research &design institute B4 SPERI B5	
Aviation equipment manufacturing	Shanghai Turbine Company, Ltd. A26 shanghai aircraft manufacturing Co.,Ltd A27 … Shanghai aerospace electronics Co.,Ltd A29	china aeronautical radio electronics research institute B6 … Shanghai aerospace measurement and control technology institute B8	
Satellite equipment manufacturing	HT-SAAE A30 shanghai composite materials Co.,Ltd A31 … Shanghai aerospace power technology engineering Co.,Ltd A33	Shanghai institute of satellite engineering B9 … Shanghai aerospace precision machinery research institute B13	
Rail transportation equipment manufacturing	Shanghai shentong orbit transportation research and consulting Co.,Ltd A34 … SMT shanghai magiev transportation A44	STEDI B14… Shanghai railway institute of science and technology B18	
Intelligent equipment manufacturing	Baosight A50 … shanghai capital numerical control Co.,Ltd A63	Shanghai mechanical and electrical industry technical supervision B19 … SIPAI B22	

3. Cooperative Innovation Network Analyses

3. 1 Structure Analysis of Cooperative Innovation Network

Network Centralization and Density of the network are two important and complementary measurements in social network analysis. We can measure the quality of relationships among main bodies in general network and ability to get innovation resources with destiny indicator[ix]. On the other hand, Network Centralization, reflecting the right concentration of the network, is an indicator to measure Centralization of a main body to others in Network[x].Mathematical expressions and the results of Density and Network Centralization are as follows:

$$Density=\frac{2L}{g(g-1)}$$

L is the total number of connection in network, g is the number of nodes in network

$$Centralization=\frac{\sum_{i=1}^{n}(C_{D\max}-C_{Di})}{\max\sum_{i=1}^{n}(C_{D\max}-C_{Di})}$$

C_{Di} is the centralization of the node, and $C_{D\max}$ is the largest center value in figure.

Density (matrix average) =0.0867
Standard deviation =0.362
Network Centralization=26.14%

From the results of the analysis, the overall network density is 0. 0867, the standard deviation of relations is 0. 362. The network relationship is thin and completeness is low, reflecting low degree of organization cooperation of the innovation system and huge development space to promote the cooperation between institutions.

The whole Network Centralization is 26.14% means the network has a tendency to concentrate and the entire network organize together around some institutions to some extent. For another, the value is not so large infers "rights" in the network is more dispersed and presents structure of "decentralization". This characteristic is caused by network environment made of multiple fields' institutions and history, social and cultural background in the development of the regional economic structure, and other related factors.

4. Conclusions and Relevant Policy Recommendations

This study starts from perspective of social network and it is also the main analytical tools and gets the following conclusion based on analyzing the industry—university—institute cooperation innovation network of Shanghai high-end equipment manufacturing industry:

a) The relationships in the overall network is sparse and completeness is low there is a big space to further promote industry-university-institute cooperation innovation; Overall network centralization is moderate and presents the structure of the " decentralization"
b) Universities and research institutions have high heterogeneity and irreplaceability; backbone enterprises take the leading role in the development of in the industry but are always weaker in terms of knowledge sharing and dissemination
c) (3)Industry technology alliance or industry association has become an important form of local cooperation innovation network, and the structural similarity between members is high. The network has become an important part in high and new technology enterprise innovation.

In the knowledge economy as the main characteristics and economic globalization situation, cultivating and improving the regional innovation system mainly refers to cultivate the cooperative innovation network and optimize the structure of cooperative innovation network. So the recommends are as follows:

(1) Set up industry technology alliance or production alliance to optimize the network based on multiple institutions. Promote a regional personalized innovation project and make these projects make full use of all kind resources from university, scientific research institutes and enterprise in Shanghai. Then, integrate intellectual innovation resources and improve the efficiency of innovation.
(1) (2) Strengthen the leading role of authority in aspects of technology. Guide the extravert enterprises and institutions establish themselves in local[xi], for example, the government can encourage the university to provide technical support for local enterprises. At the same time, there are commons in this field of high-end equipment manufacturing industry, thus we should promote fuse of industrial technology between different areas so that make technology breakthrough come true.
(2) To ensure that the traditional industry in Shanghai has continued competitiveness, priority policy should be to promote industry technology upgrading, improve the network in the field of equipment manufacturing. Construct industry oriented development base or national and provincial technology center and R&D center relying on scientific research institutes or backbone enterprises actively. Provide intellectual support for the technology upgrading of traditional industry.

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