# A Regional University-Industry Cooperation Research

# Based on Patent Data Analysis

Hui Xu

Department of Economics and Management Harbin Institute of Technology Shenzhen Graduate School Shenzhen 518055, China Tel: 86-755-2603-3494 E-mail: xuhui5859@126.com

#### Abstract

Regional university-industry cooperation has been focused because it improves innovation ability of enterprises and regions. The paper uses regional patent data from 2001 to 2008 to measure regional university-industry cooperation. By carefully data disposition, we get patent data records representing regional university-industry collaboration. Through patent data analysis from different angles and comparison of geographic knowledge flows, this paper describes the situation of regional university-industry cooperation. Then social network analysis method is adopted to depict how universities, scientific research institutes and enterprises co-work to innovate. In virtue of the method, we acquire visualization of cooperation microstructure. Five kinds of sub cooperation network are distinguished to study the cooperation. These findings can be used to measure regional university-industry cooperation and put forward improving suggestions.

Keywords: University-industry cooperation, Patent data, Social network analysis, Visualization

# 1. Introduction

University-industry cooperation means innovation cooperation between enterprises and universities, or between enterprises and scientific research institutes. The cooperation transfers tangible technical results or intangible technical knowledge from university to industry. In this process, universities and scientific research institutes are usually the main body of knowledge innovation, and enterprises are usually the main body of technology innovation. These sections jointly innovate and turn technological achievements to products. Their cooperation can improve effectively innovation ability of enterprises and the whole region.

Many researches about cooperation mode and mechanism have been done for university-industry cooperation. Rusum (1972), Bolton (1994) analyzed university-industry cooperation mode. Richard and Robert (1983) examined the events in the transfer of an advanced technology from the university group to an industrial firm. Dierdonck, Debackere and Engelen (1990) examined the attitudes of the Belgian academic community towards university-industry technology transfers. Geisler (1995) proposed a grounded theoretical framework of R&D technology cooperation based on the congruence of existing theories of inter-organizational relationships. Lee (1996) conducted a survey of an estimated 1000 US university professors from 115 schools to assess their stand on technology transfer and university-industry partnership. Meyer-Krahmer and Schmoch (1998) found that in science-based fields, university departments have a distinct focus on basic research and the major interest of industry is the observation of science. In less science-based fields, the solution of technical problems is a major concern of industry. In all fields, the exchange of knowledge in techno-scientific communities is a crucial element of interaction. Carayannis (1999) proposed a dynamic, learning-driven framework to examine how a knowledge generating and leveraging value-maximizing organization, MacPherson (2002) examined the role of academic-industry linkages in the innovation performance of New York State manufacturers of medical devices and revealed that non-geographic factors play a stronger role overall. Motohashi (2005) found that university-industry cooperation is not simply adaptations of technology at university, but involves significant development activities at industry side. These researches show that how academies and enterprises cooperate will affect their innovations.

Some researchers have begun to analyze university-industry cooperation through patent data analysis. Margherita and Andrea (2006) used patent data integrated with information collected through interviews and measured the extent and intensity of the ties of academic with industrial researchers, and apply social network

analysis to reconstruct the network of collaborations. Motohashi (2008) used patent data in China and found that the cooperation between enterprises and universities become closer, while the cooperation between enterprises and scientific institutes gradually slow down. Chen (2007) studied outputs of Chinese patents and explored the composition of contribution force of university-industry cooperation for Chinese technological innovation. The result showed that technological innovation ability of university-industry cooperation play a dominant position of regional innovation. Chen (2007) reviewed patent actualization of Chinese universities and compared researches of U.S. university patents. From technical features of university patents, patent application characteristics and the implementation of the environment, he analyzed patent problems in China University patent actualization. Hong (2008) took advantage of Chinese patent data and examined the geographic variations in university-industry collaborations in China from 1985 to 2004 and showed a decentralizing/localizing trend in knowledge flows from university to industry.

Patent reflects technological level of technology innovation ability and developing degree of technical markets of a country or a region. It reflects competitive strength of science and technology. Also it forms intellectual property rights and enhances core competitiveness capability of enterprises. According to the above literature reviews, some scholars studied university-industry cooperation through the use of patent databases, but most of them are focused on knowledge flows and in national level, regional university-industry cooperation is rare. Based on patent data analysis of Shenzhen enterprises and other region universities or research institutions, Shenzhen universities or research institutions and other region companies from 2001 to 2008, the paper tries to analyze regional university-industry cooperation in depth. Our study is similar to Hong (2008), but we focus on cooperation in a region.

#### 2. Data

#### 2.1 Data resource

The State Intellectual Property Office of China provides a dataset with complete patent information since 1985. The database includes the names of inventions; the dates of application, publication, and grant; the names and addresses of inventors and assignees; and industry categories.

#### 2.2 Data disposition

There are three types of patent in China: invention patent, utility patent, and design patent. This paper uses patent applications of all kinds.

Taking into account most of patents with 18-month review period, the data of 2009 and 2010 were counted partly. Thus the data of the last two years are deleted. In addition, the patents number of Shenzhen before 2001 is few (Shown in Table 1). Finally the data range is 8 years from 2001-2008.

By examining the assignee information, the paper identifies patents applied for by universities and firms as co-applicants. We sort out patent record applied for universities and enterprises, or scientific institutes as co-applicants by examining the assignee information (see Hong, 2008). Resembling to Hong (2008), we set search conditions and access patents jointly applied for by industrial and academic sectors in which one is of Shenzhen. For industrial sectors, assignee names could be a company (Gongsi), a factory (Chang), a group (Jituan), an enterprise (Qiye), or a combination of several of them(e.g., Qiye Jituan Gongsi); for academic sectors, the assignee names could be a university (Daxue), a college(Xueyuan), a research institute(Yanjiusuo or Yanjiuyuan), a scientific institute(Kexueyuan), a general research institute(Yanjiuzongyuan), a research center(Zhongxin). And one of assignee names in every patent record must have 'Shenzhen'.

So we get 28 search combinations and 1332 Shenzhen university-industry collaboration cases in total. The actual number of valid records is much smaller because some records are overlapped (when use different search conditions) and some cases were actually applied for by one entity. After further data disposition, 759 records remained. By identifying all firms, universities and scientific research institutes, we take a sector record which had 241 different sectors.

# 2.3 Data analysis

After data disposition, we analyze the records from different angles.

In Figure 1, the patent application number includes the numbers of invent patent, utility patent and design patent. The figure shows that patent application number of university-industry cooperation has increased promptly from 2001 to 2008. Since 1999, local government has presented many policies to encourage innovation and university-industry cooperation. For example, Shenzhen government constituted policies to give financial aids to technological progress of enterprises. Many famous university and research institutes started to found Shenzhen

branches. National key laboratories and national engineering centers are open to firms. Many postdoctoral workstations have been set up. These measures advance the cooperation so that patent application number increases quickly.

Figure 2 shows changes of invent patent, utility patent and design patent individually. The number of utility patent and that of design patent both are very low. So we can conclude that Shenzhen university-industry cooperation focuses on invent patent. Figure 3 gives the ratio of inventor patent co-applicants to all the Shenzhen patent applicants every year. The ratio changes are not very large. Why patent application numbers increase promptly but the ratio changes smoothly? We think innovation encouraging measures spur not only the innovation of university-industry cooperation but also the innovation of inter-enterprises.

Figure 4 gives the comparison of geographic knowledge flows in all 759 records. Most of records are knowledge flows from other provinces (cities) university (scientific research institutes) to Shenzhen enterprises. The records of that from Shenzhen to Shenzhen and from Shenzhen to other provinces are low. These suggest local university-industry cooperation is not enough because local university (scientific research institutes) strength has deficiency. Figure 5 gives the ranking top 8 provinces (cities) in which universities are located in. Most of these provinces (cities) are advanced provinces (cities). This result is consistent with Hong (2008) and confirms his conclusion that there exists a link between active university knowledge transfer and economic development.

# 3. Social network analysis

# 3.1 Method introduction

Social network analysis is a kind of multi-disciplinary analysis method combined with mathematics, statistics and computer science. Social network analysis focuses on the process of change and overall interaction. The key of social network analysis is to characterize complex and diverse patterns as a certain network configuration. Based on these configurations and their changes, the method describes their individual actions and the significance of social structure.

Wellman and Berkowitz outlined the basic principles of network analysis: (1) The world is formed by the network, not the composition of the group; (2) Explaining social behavior and social relations is more important than the characteristics of the community members; (3) The rules of the actors how to act is from location of social relation structure system; (4) Only in the social network structure one can be understood how "ties" operate. Social structure network will affect social resources allocation in relationship; (5) The unit of research of network structure is the relationship, rather than individuals.

# 3.2 Social network analysis application in innovation studies

Social network analysis in innovation research is one of its main applications. As the advantage of social network analysis is to reveal the role of social institutions with an overall view of the process and study the interaction between nodes, it is suitable for innovation research. A number of Chinese scholars have conducted research using social network analysis and the innovation-related issues have begun to be analyzed. Yang used social network analysis to construct three key network variables: the degree, the intermediary and the effective scale to measure network location of enterprises in the cell phone industry cluster of Hang Zhou. The results showed that: the degree of the network location of enterprises and the effective size has significant statistical correlation with enterprise innovation, while the intermediary is not statistically significant. Huang found that the innovative mechanism and performance of industrial clusters are from the network structure.

#### 4. Results and analysis

Because social network analysis is suitable for revealing the role of social institutions and studying the interaction between nodes, the paper analyzes regional university-industry cooperation with the method. All the units are extracted from the 759 records and the duplicates are removed. Finally, a  $241 \times 241$  unit matrix is formatted. Then the paper uses NetDraw (NetDraw is a program for social network analysis) to analyze the matrix. Figure 6 is the visualization result. Because the names of units are too long to show in the figure, we use number code to denote.

In the figure, each point represents a university (scientific research institute) or a firm. The link between two points means they have co-application patents.

Five kinds of sub cooperation network are distinguished to study the cooperation (The five kinds of sub cooperation network have been used to analyze co-author papers by Liu and Yuan, 2008).

Two core style: In the sub network there are only two nodes. It means that the Shenzhen university (scientific research institute) or the enterprise in the sub network cooperate with one corresponding sector (e.g., node71-72).

Streamline style: In the sub network there are nodes whose number is greater than 2. The nodes are connected as lines (e.g., node 117-23-28). This sub cooperation network has no core node.

Kernel style: There is an important node in kernel style and other nodes are connected with the node. The network appears outward diffusion. The key node is very important in the cooperation (e.g., kernel node 20).

Bridge style: In this style, a node links two sub network Similar to kernel style, the linkage node is the key point (e.g., bridge node 130).

Netback style: The nodes in this style are connected with each other. This style is rather stable (e.g., node 191-192-193-194)).

In the cooperation network shown in Figure 6, there are all the five kinds of sub network. Two core style and streamline style are familiar style in university-industry cooperation. Kernel style, bridge style and netrack style networks are comparatively few. In information science, the last three styles are considered more stable in network structure and knowledge transfers more smoothly. The enterprises could use the cooperation network to improve affiliations with academic institutes.

# 5. Conclusion

Patent data analysis of co-application can reflect cooperating situation of university-industry. Quantitative analysis and social network analysis of patent data conduct visualizing identification and evaluation of university-industry cooperation.

First, patent data are easily gotten so that we can conveniently used to track and analyze cooperation effects in order to develop and evaluate corresponding policies. Secondly, we can find high output clusters and search their innovation experiences to create more innovations. Also, problems existed in cooperation can be easily found to make improvement and policy guidance. For example, the appropriate groups can found to take preferential measure and give financial aids.

Further research will be extended in two directions. Our paper only analyzes the situation of Shenzhen and the next step is that other cities situation would be studied and be compared. Furthermore, the sub network cooperation can be further analyzed to find cooperative patterns.

# References

Bolton, R. (1994). A broader view of university-industry relationships. Journal of the Society of Research Administrators, 26(3/4), 45-48.

Carayannis, E. G., Alexander, J. (1999). Winning by co-opeting in strategic government-university-industry R&D partnerships: the power of complex, dynamic knowledge networks. *Journal of Technology Transfer*, 24(2), 197-210.

Chen, H. Q., Song, Z. Q., Yang, M. (2007). Factors analysis and primary study on the patents implementation in Chinese universities. *Research and Development Management*, 19(4), 102-106.

Chen, Y. W., Yang, Z. P., Fang, S., Wen, Y., Hu, Z. Y., Deng, Y., Wang, C. (2007). Ability analysis of Chinese technological innovation based on invent patent status. *Science and Technology Management Research*, 6, 9-12.

Dierdonck, R. V., Debackere, K., Engelen, B. (1990). University-industry relationships: How does the Belgian academic community feel about it? *Research Policy*, 19(6), 551-566.

Geyser, E. (1995). Industry-university technology cooperation: A theory of inter-organizational relationships. *Technology Analysis & Strategic Management*, 7(2), 217-229.

Hong, W. (2008). Decline of the center: The decentralizing process of knowledge transfer of Chinese universities from 1985 to 2004. *Research Policy*, 37, 580-595.

Huang, Z. W. (2004). On the network of enterprise clusters and its advantages in their innovation. *Journal of Ningbo University (Liberal Arts Edition)*, 17(3), 94-97.

Lee, Y. S. (1996). 'Technology transfer' and the research university: a search for the boundaries of university-industry collaboration. *Research Policy*, 25(6), 843-863.

Liu, B., Yuan, Y. (2008). Application of social network analysis in information science. *Journal of the China Society for Scientific and Technical Information*, 27(3), 407-417.

MacPherson, A. (2002). The contribution of academic-industry interaction to product innovation: the case of New York State's medical devices sector. *Papers in Regional Science*, 81(1), 121-129.

Margherita, B., Andrea, L. (2006). University-industry interactions in applied research: The case of microelectronics. *Research Policy*, 35(10), 1616-1630.

Meyer-Krahmer, F., Schmoch, U. (1998). Science-based technologies: University-industry interactions in four fields. *Research Policy*, 27(8), 835-851.

Motohashi, K. (2005). University-industry collaborations in Japan: The role of new technology- based firms in transforming the National Innovation System. *Research Policy*, 34(5), 583-594.

Motohashi, K. (2008). Assessment of technological capability in science industry linkage in China by patent database. *World Patent Information*, 30(3), 225-232.

Richard, S. G., Robert, T. L. (1983). University-to-industry advanced technology transfer: A case study. *Research Policy*, 12(3), 121-152.

Roy, R. (1972). University - industry interaction patterns. Science, 178 (4064), 955-960.

Wellman, B., Berkowitz, S.D. (Eds.). (1988). Social structures: A network approach. Cambridge: Cambridge University Press, pp. 19-61.

Yang, R., Huang, G. A. (2005). Network position and innovation-Social network analysis of Hang Zhou mobile industry clusters. *Industry Technological Economy*, 24 (7), 114-118.

			-	-	-	-	-	-	-		
Patent Types	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Invention patent	2	5	4	5	18	16	20	26	41	34	71
Utility patent	4	12	15	24	36	44	70	87	102	130	178
Design patent	2	5	44	22	31	117	139	269	303	460	599
Patent Types	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Invention patent	109	302	330	539	948	1172	1657	3315	4539	6465	8277
Utility patent	261	531	670	940	1195	1539	1752	1951	2354	3174	4564
Design patent	754	944	1246	1477	1650	1723	1793	1939	2484	2735	2998

Table 1. Shenzhen Patent Application in 1987-2008

The data in the table are searched by assignee names with 'Shenzhen'.







Figure 2. The patent application number individually



Figure 3. The ratio of inventor patent co-applicants to all the Shenzhen patent applicants (%)



Figure 4. The comparison of geographic knowledge flow



Figure 5. The provinces (cities) ranking in top 8 in which universities are located



Figure 6. The cooperation network