Searching for China's Regional Innovation Poles and Holes based on the Scientometrics of Regional Patent Collaboration data

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ABSTRACT

1 Research Background

"Innovation" activities in the developed countries greatly enhanced their competitiveness and accelerated the process of global economic integration. In recent years, it has also increasingly become an important factor influencing China's economy. Since 2001, "Annual Report of China's regional innovation capability" (2001-2006) which written by Professor LIU Xielin and other scholars began publish. The studies noted that some regional part (such as the Yangtze River Delta area, Guangdong, Zhejiang, etc.) has been achieved good innovation results, and some regions are still groping in the attempt to the process of innovation, China has formed a four sectors of the innovation echelon.

Then, what factors affected the accumulation of regional innovation capacity and the level of regional innovation performance? And how the factors affected the forming of China's regional innovation system (RIS)? Above two questions became important issue in exploring China's RIS.

At the research beginning of "RIS" theory, scholars has pointed out that the features of RIS is interactive learning and cooperation (Cooke, 1996). Chinese scholar (PENG Jisheng, QIAO Ying, HUO Yun Fu) also presented that only through strengthening of regional interaction between the various elements of cooperation, such like the enterprises, colleges and governments, the regional innovation vitality would be enhanced. Chen Jin and others (2006) draws on the international advanced innovative management theory, "open innovation" concept was concluded. "Open innovation" theory stressed the deeper level collaboration in the broader Innovation System.

However, although the building of RIS is a so important thing, because of China's natural formation of the regional innovation system is mainly based on the demarcation of the administration regions, in the current administration system, this formation of innovative system may often be enhanced as administration region, and artificially cut off a very important innovation ties and cooperation, reduced the innovation efficiency of RIS and national innovation system. Because of these, the establishment of inter-regional innovation collaboration became more important.

Scientometrics scholars also found that region research collaboration is closely related to region research performance (Liang Liming, Zhu Ling, 2002). Their research conclusion is high performance region was not inclined to collaborate and low performance region was inclined to collaborate. The relative data come from CSCD Database and the research sample is science co-authored papers.

The same focused finding of innovation management and scientometrics scholars is "inter-regional collaboration is important, and relationship between collaboration and region performance is existed". But the conclusions come from theory deducting and statistical analyze

are not so consistent. That brings on an interesting and important research issue in this article. And according to innovation activities, research paper is not a very good sample, or to say, it is not a representative sample. Conclude the previous studies, patents data is more perfect sample.

In this article, we collected innovation data (patents) to investigate China's inter-regional collaboration. The research emphases are how China's region collaboration web is, whether there exists some innovation poles and holes or not, and what they are. In LIU's studies, he has found some strong and weak regions in China's RIS through analyzing semi-quantitative data. And in other scholars' studies, they often used USPTO (United States Patent and Trademark Office) patents data to analyze China's innovation activities , that is also not a good sample to analyze China's inter-regional innovation collaboration. In this article, we searched for the relative patents data from Patent Database Service Platform (www.cnipr.com) which based on the data of China's State Intellectual Property Office to investigate the characteristics of China's region collaboration.

2 Data and Method

In this article, we searched for patents collaboration data from "Chinese 1985-2007 Patent Database". The dimensions of the patents collaboration matrix are the style of patents (I: invention patent, D: design patent, U: utility patent) and the collaborative region (China's 33 administration region including Hong Kong and Macao, but Taiwan).

Table 1 China's inter-regional patents collaboration data matrix (initial matrix)

region	Beijing			Shanghai			Guangdong			Jiangsu			Zhejiang			Shandong			Tianjin			Liaoning			Fujian			Chongqing			Sichuan			Jilin			.....
style of patent	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	I	D	U	.....
Beijing				62	24	30	8	0	15	11	1	3	13	2	12	16	0	31	28	4	34	3	0	2	1	1	6	7	1	6	4	0	2	18	4	9	.....
Shanghai							1	0	2	24	2	21	116	9	38	7	0	1	12	2	5	0	0	0	2	0	1	26	1	4	4	2	2	11	31	11	.....
Guangdong										2	0	0	1	0	1	0	18	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.....
.....																																					

During searching the patent data on CNIPR web, we only typed in "'A region' and 'B region'" to get the A and B collaboration I/D/U frequencies, there isn't sequence between A and B, so the initial matrix is a semi-matrix.

In the initial semi-matrix, we get 1763 collaborative frequencies between 33 regions, including 766 frequencies of "invention patent", 335 frequencies of "design patent" and 662 frequencies of "utility patent".

In order to investigate the ranking between 33 regions and observe the holistic distribution status quo using the collaborative data, we changed the semi-matrix to the whole symmetrical matrix and ranked the regions as their each collaborative frequency. Then we get four observed matrixes: "sum" matrix, "I" matrix, "D" matrix and "U" matrix.

In Table 2, we calculated each region's collaborative frequencies with other 32 regions, so the "total" datum in last row we get "3526", it equals to 2×1763 (total frequencies of semi-matrix).

Table 2 Collaborative frequencies of each region

Rank	Region	Total collaborative frequencies	Collaborative frequencies of Invention patent	Collaborative frequencies of Design patent	Collaborative frequencies of Utility patent
1	Shanghai	640	352	88	200
2	Zhejiang	549	187	188	174
3	Beijing	540	275	49	216
4	Jiangsu	381	74	170	137
5	Tianjin	215	102	13	100
6	Shandong	113	40	19	54
7	Hainan	108	25	15	68
8	Chongqing	107	50	19	38
9	Jilin	95	34	35	26
10	Hebei	95	45	2	48
11	Sichuan	77	38	7	32
12	Guangdong	69	20	18	31
13	Shanxi	56	30	1	25
14	Henan	54	19	2	33
15	Yunnan	51	31	6	14
16	Hunan	45	22	10	13
17	Anhui	44	32	1	11
18	Guangxi	42	30	5	7
19	Hubei	29	14	3	12
20	Jiangxi	29	11	3	15
21	Neimenggu	25	15	3	7
22	Guizhou	25	18	5	2
23	Fujian	24	7	3	14
24	HongKong	20	9	0	11
25	Ningxia	18	7	0	11
26	Shan'xi	16	13	0	3
27	Xinjiang	16	9	5	2
28	Heilongjiang	13	3	0	10
29	Liaoning	12	5	0	7
30	Gansu	10	7	0	3
31	Qinghai	7	7	0	0
32	Xizang	1	1	0	0
33	Macao	0	0	0	0
Total		3526	1532	670	1324

Table 3 Matrix of Collaborative frequencies between 33 regions

"sum" matrix		1	2	3	4	5	6	7	8	9	10	…
		Shanghai	Zhejiang	Beijing	Jiangsu	Tianjin	Shandong	Hainan	Chongqing	Jilin	Hebei	…
1	Shanghai		163	117	47	19	8	90	31	53	1	
2	Zhejiang	163		27	295	5	2	1	6	0	1	
3	Beijing	117	27		15	66	47	4	14	31	27	
4	Jiangsu	47	295	15		1	2	1	0	0	1	
5	Tianjin	19	5	66	1		10	7	3	3	55	
6	Shandong	8	2	47	2	10		0	1	0	5	
7	Hainan	90	1	4	1	7	0		2	0	0	
8	Chongqing	31	6	14	0	3	1	2		0	0	
9	Jilin	53	0	31	0	3	0	0	0		0	
10	Hebei	1	1	27	1	55	5	0	0	0		
…	…											

Table 4 Invention patent Matrix (“I” matrix for short)

"I" matrix		1	2	3	4	5	6	7	8	9	10	…
		Shanghai	Beijing	Zhejiang	Tianjin	Jiangsu	Chongqing	Hebei	Shandong	Sichuan	Jilin	…
1	Shanghai		62	116	12	24	26	1	7	4	11	
2	Beijing	62		13	28	11	7	13	16	4	18	
3	Zhejiang	116	13		3	25	0	1	1	4	0	
4	Tianjin	12	28	3		0	2	26	7	0	2	
5	Jiangsu	24	11	25	0		0	1	0	2	0	
6	Chongqing	26	7	0	2	0		0	1	8	0	
7	Hebei	1	13	1	26	1	0		1	0	0	
8	Shandong	7	16	1	7	0	1	1		1	0	
9	Sichuan	4	4	4	0	2	8	0	1		0	
10	Jilin	11	18	0	2	0	0	0	0	0		
…	…											

Table 5 Design patent Matrix (“D” matrix for short)

"D" matrix		1	2	3	4	5	6	7	8	9	10	…
		Zhejiang	Jiangsu	Shanghai	Beijing	Jilin	Shandong	Chongqing	Guangdong	Hainan	Tianjin	…
1	Zhejiang		166	9	2	0	0	5	0	0	0	
2	Jiangsu	166		2	1	0	0	0	0	0	0	
3	Shanghai	9	2		24	31	0	1	0	13	2	
4	Beijing	2	1	24		4	0	1	0	0	4	
5	Jilin	0	0	31	4		0	0	0	0	0	
6	Shandong	0	0	0	0	0		0	18	0	1	
7	Chongqing	5	0	1	1	0	0		0	1	1	
8	Guangdong	0	0	0	0	0	18	0		0	0	
9	Hainan	0	0	13	0	0	0	1	0		0	
10	Tianjin	0	0	2	4	0	1	1	0	0		
…	…											

Table 6 Utility patent Matrix (“U” matrix for short)

"U" matrix		1	2	3	4	5	6	7	8	9	10	…
		Beijing	Shanghai	Zhejiang	Jiangsu	Tianjin	Hainan	Shandong	Hebei	Chongqing	Henan	…
1	Beijing		31	12	3	34	1	31	13	6	13	
2	Shanghai	31		38	21	5	59	1	0	4	3	
3	Zhejiang	12	38		104	2	0	1	0	1	1	
4	Jiangsu	3	21	104		1	0	2	0	0	1	
5	Tianjin	34	5	2	1		7	2	28	0	12	
6	Hainan	1	59	0	0	7		0	0	1	0	
7	Shandong	31	1	1	2	2	0		4	0	2	
8	Hebei	13	0	0	0	28	0	4		0	0	
9	Chongqing	6	4	1	0	0	1	0	0		0	
10	Henan	13	3	1	1	12	0	2	0	0		
…	…											

Based on the collaborative patent data, we could investigate two important ideas:

- To distinguish strong collaboration region (innovation poles) and weak collaboration region (innovation holes), analyze their characteristics of collaborative web.
- To analyze the difference of “invention patent” matrix, “design patent” matrix and “utility patent” matrix, found the innovation predominance of some strong collaborative innovative regions.

According to these two ideas, in this article, we used mainly frequency and rank analyses to

do the research works. It's a useful method to analyze collaborative holes and poles between regions. Firstly, we ranked "sum" matrix as each region's total collaborative frequencies. Secondly, each region's 32 collaborative partners were ranked by their collaborative frequencies. Thirdly, we list every region's 10 closed collaborative partners as their collaborative frequencies, then we could get "10×33=330" regions. When we observed the 330 regions and its each frequencies, we found that Xizang region has only 1 partner, it is Beijing; Macao has no partner, that is, its total collaborative frequency is 0. So we decided delete the partners of Xizang and Macao, the number of regions which used to analyze innovation holes is "10×31=310". Fourthly, we calculated the times of each region in the 310 regions.

Use the same method, we observed the "0" collaborative partners of 33 regions and calculated their emerging times, we named these regions as "regional innovation holes".

Table 7 Innovation Poles and Holes regions

Rank	Innovation Poles	Frequencies as closed parters
1	Shanghai	32
2	Beijing	31
3	Tianjin	31
4	Zhejiang	29
5	Jiangsu	25
6	Shandong	23
7	Chongqing	22
8	Hainan	16
9	Jilin	11
10	Shanxi	11

Rank	Innovation Holes	As "0" collaborative partners
1	Macao	32
2	Xizang	31
3	Gansu	27
4	Ningxia	27
5	Qinghai	27
6	Heilongjiang	26
7	Hongkong	26
8	Xinjiang	26
9	Guizhou	25
10	Neimenggu	25

Table 8 31 region's closed partners

Region	High collaborative parters (except Xizang and Macao)									
	1	2	3	4	5	6	7	8	9	10
Shanghai	Zhejiang	Beijing	Hainan	Jilin	Jiangsu	Chongqing	Yunnan	Tianjin	Guangxi	Shanxi
Zhejiang	Jiangsu	Shanghai	Beijing	Yunnan	Jiangxi	Guizhou	Chongqing	Hunan	Tianjin	Sichuan
Beijing	Shanghai	Tianjin	Shandong	Jilin	Zhejiang	Hebei	Guangdong	Henan	Shanxi	Neimenggu
Jiangsu	Zhejiang	Shanghai	Beijing	Anhui	Sichuan	Shandong	Guangdong	Henan	Tianjin	Hainan
Tianjin	Beijing	Hebei	Shanghai	Henan	Shandong	Hainan	Zhejiang	Yunnan	Xinjiang	Chongqing
Shandong	Beijing	Guangdong	Tianjin	Shanghai	Hebei	Anhui	Sichuan	Henan	Zhejiang	Jiangsu
Hainan	Shanghai	Tianjin	Beijing	Chongqing	Zhejiang	Jiangsu	Guangxi	Xinjiang	Qinghai	Shandong
Chongqing	Shanghai	Sichuan	Beijing	Hunan	Zhejiang	Hongkong	Tianjin	Guizhou	Hainan	Guangxi
Jilin	Shanghai	Beijing	Tianjin	Shan'xi	Guangdong	Shanxi	Guangxi	Neimenggu	Liaoning	Gansu
Hebei	Tianjin	Beijing	Shandong	Shanxi	Shanghai	Zhejiang	Jiangsu	Hunan	Liaoning	Hainan
Sichuan	Chongqing	Yunnan	Shanghai	Guizhou	Beijing	Zhejiang	Jiangsu	Shandong	Xinjiang	Tianjin
Guangdong	Beijing	Shandong	Hubei	Shanghai	Zhejiang	Jiangsu	Hunan	Tianjin	Jilin	Shanxi
Shanxi	Beijing	Shanghai	Ningxia	Hebei	Tianjin	Sichuan	Jiangsu	Shandong	Chongqing	Jilin
Henan	Beijing	Tianjin	Shanghai	Zhejiang	Shandong	Jiangsu	Shanxi	Yunnan	Hubei	Heilongjiang
Yunnan	Shanghai	Sichuan	Zhejiang	Beijing	Tianjin	Chongqing	Henan	Jiangsu	Shandong	Hainan
Hunan	Beijing	Chongqing	Zhejiang	Hubei	Guizhou	Qinghai	Shanghai	Sichuan	Guangdong	Tianjin
Anhui	Beijing	Shanghai	Jiangsu	Shandong	Tianjin	Chongqing	Guangdong	Hunan	Hubei	Zhejiang
Guangxi	Shanghai	Beijing	Chongqing	Zhejiang	Hainan	Jilin	Guangdong	Shanxi	Fujian	Liaoning
Hubei	Beijing	Guangdong	Shanghai	Hunan	Chongqing	Fujian	Ningxia	Tianjin	Henan	Anhui
Jiangxi	Shanghai	Zhejiang	Beijing	Fujian	Jiangsu	Shanxi	Hunan	Heilongjiang	Tianjin	Shandong
Neimenggu	Beijing	Tianjin	Shanghai	Zhejiang	Jilin	Shanxi	Hunan	Jiangsu	Shandong	Hainan
Guizhou	Zhejiang	Sichuan	Beijing	Chongqing	Hunan	Jiangsu	Tianjin	Shanghai	Shandong	Hainan
Fujian	Beijing	Shanghai	Tianjin	Sichuan	Hubei	Jiangxi	Zhejiang	Jiangsu	Chongqing	Guangxi
HongKong	Chongqing	Shanghai	Beijing	Sichuan	Tianjin	Guangdong	Zhejiang	Jiangsu	Shandong	Hainan
Ningxia	Shanxi	Beijing	Hubei	Chongqing	Shan'xi	Shanghai	Zhejiang	Jiangsu	Tianjin	Shandong
Shan'xi	Beijing	Shanghai	Jilin	Shandong	Ningxia	Xinjiang	Qinghai	Zhejiang	Jiangsu	Tianjin
Xinjiang	Beijing	Tianjin	Sichuan	Shanghai	Hainan	Shan'xi	Zhejiang	Jiangsu	Shandong	Chongqing
Heilongjiang	Beijing	Zhejiang	Shandong	Tianjin	Henan	Jiangxi	Shanghai	Jiangsu	Hainan	Chongqing
Liaoning	Beijing	Zhejiang	Tianjin	Chongqing	Jilin	Hebei	Guangxi	Fujian	Shanghai	Jiangsu
Gansu	Zhejiang	Shanghai	Beijing	Jilin	Shanxi	Jiangsu	Tianjin	Shandong	Hainan	Chongqing
Qinghai	Hunan	Shanghai	Tianjin	Hainan	Shan'xi	Zhejiang	Beijing	Jiangsu	Shandong	Chongqing

3 Analyses and Results

A. China's Regional Innovation collaboration Poles

According to Table 7, we could find East-South China is still the most active innovation collaboration region compared with their high economy development speed. It includes Shanghai, Zhejiang and Jiangsu. Compared to them, Beijing, Tianjin and Shandong Regions is another high innovation collaboration region. And there arise an important innovation collaboration region in West-South China, Chongqing. As the fourth municipality directly under the Central Government in China, it has been leading innovation region in West-South China. Through the high innovation collaboration with Sichuan, Hunan and Guizhou, it becomes a more and more important innovation poles in China. The same important emerging region is Hainan, the most south region in China. These years, Hainan collaborated with active innovation region, such like Shanghai, Tianjin, Beijing, etc.. We could expect Hainan will be next new innovation region and developed economy in China.

B. China's Regional Innovation collaboration Holes

As showing in right list of Table 7, we find some undeveloped economy regions, such as Xinjiang, Gansu, Ningxia, Qinghai, etc. still are the high non-collaborative regions. Another, Hong Kong, Macao Special Administrative Regions are also the high non-collaborative regions with other regions on China mainland, but they are also most active economic regions in the world, they have not been the closed innovation partners with China mainland apparently. The fact warns us that we should make closed innovation collaboration and economic relationship with Hang

Kong, Macao, it would bring some important innovation chances to China mainland.

C. Characteristics in "I", "D" and "U" collaborative matrixes

According to Table 4-6, we could find that:

- ◇ Shanghai is the most invention patent collaborative region;
- ◇ Zhejiang is the most design patent collaborative region;
- ◇ Beijing is the most utility patent collaborative region.

Generally, invention patent will be seen as a high innovation competence, next is design patent, last is the utility patent. The fact gives us some special feeling, that is, Beijing, the capital of China, it is the political and cultural center. But in our innovation collaborative map, Beijing is not still the center, its leading station is challenged. It also demonstrated the diversified trend in China nowadays.

And there is also a noteworthy problem: ratio between total number of "invention patent" and "design patent"=1532:670≈2.3:1. In innovation management theory and many case studies, we have found the rational ratio between "product innovation" and "process innovation" is 1:2. As we know, invention patent almost leads to product innovation, and design leads to process innovation. So the two ratios is poles apart. We think that it may be an important reason of China's low innovation competence. Of course, when we calculate the ration between "invention patent" and "design+utility patent", we could get "1532:1994≈1:1.3", it also has some distance with "1:2".

4 Discussions and Conclusions

During this research process, we found the fact of China's regional innovation collaborative poles and holes in faith. Specially, we found an emerging new innovation collaborative region, Hainan. Next, China has presented a diversified trends, Shanghai, Zhejiang, Beijing, Jiangsu, Shandong, even Jilin and Shanxi, they are showing more and more innovation and collaboration ability. Last, we could not ignore two question: one question is that Hong Kong and Macao are not still important collaborative partners to the regions on China mainland, we should change the fact and give better play to the role of them; another question is that the relationship between invention patent collaborative ability and design patent collaborative ability, the fact warns us that we need to expect more and more regional innovative collaboration, and also need to expect an innovative collaboration with good planning and policy guidance.

Patent scientometrics is a useful method to investigate innovation activities, but not a holistic quantificational research to innovation activities. In next studies, we will increase the innovation indicators and give a more systemic data exhibition. Maybe we could get more interesting findings to draw the "Map of China's innovative collaboration". We hope continue and deepen the research works of innovation collaboration.

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References

[1] Liu Xielin, etc.. 2006. Report of China's regional innovation capability(2005-2006). Beijing: Science Press.

[2] Cooke P, H. M. 1996. Regional Innovation Systems. UCL Press, London.
[3] Chen Jin, Chen Yufen. 2007. Resource input measurement in the open innovation condition. Science of Science research (02).
[4] C. H. 2003. Open Innovation, the new imperative for creating and profiting from technology. Haavard Business School Press,
[5] Liang, L. and Zhu, L. 2002. Major factors affecting China's inter-regional research collaboration: regional scientific productivity and geographical proximity. Scientometrics, 55(2), 287-316.
[6] Jiancheng, G. and Ying, H. 2007. Patent-bibliometric analysis on the Chinese science a€" technology linkages. Scientometrics, 72(3), 403-425.
[7] Kretschmer, H., Liming, L. and Kundra, R. 2001. Chinese-Indian-German collaboration results that provided the impetus for the foundation of COLLNET. Scientometrics, 52(3), 445-456.
[8] Edquist, C., Eriksson, M. L. and Sj, H. 2002. Characteristics of Collaboration in Product Innovation in the Regional System of Innovation of East Gothia. European Planning Studies, 10(5), 563-581.
[9] Arlette, J. 2007. Explaining international collaboration in global environmental change research. Scientometrics, 71(3), 367-390.
[10] 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.
[11] Http://www.cnipr.com

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