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The Research of Regional Collaborative Innovation Mode in China: Based on Principal Component Analysis

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Abstract

The research on regional innovation is fully developed by many researchers for these thirty years. We can found from prior researches that regional innovation subjects are the enterprise, universities, research institutions, government and intermediary organizations, and each has different functions and effects. But previous quantitative researches are mostly focused on regional innovation environment, innovation ability and the relationship between some factors and regional innovation ability, the qualitative researches about behaviors of innovation subjects is lack. So this paper will apply the principal component analysis and point out what is the mode in each region in China. This paper will supply other researchers a new method to analysis regional innovation. This paper divided into six parts: Introduction, Related researches, Index selection, Empirical research, Conclusion, Limitations.

Key words: Regional innovation subjects; Collaborative innovation; Principal component analysis; Regional innovation mode

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INTRODUCTION

On October 15, 2007, the Chinese Communist Party proposed that to improve the capability of independent innovation and build an innovation-oriented country, it is necessary to implement a strategy of revitalizing the nation through science and education, and dealing with the fierce international competition and adoption of modern industrial method. Chinese President Hu Jintao asked to actively promote collaborative innovation when actively promoting primitive and composite innovation and introduce and digest technology on the celebration of 100 anniversary of Tsinghua University On April 14, 2011. As we can see, regional innovation is an important part of national innovation, and establishing high efficiency regional innovation systems is important to improve innovation ability. In order to improve the regional innovation capability, to stimulate the initiative of innovation subjects, it is important to coordinate the relationship between innovation subjects and promote the regional cooperative innovation is more important.

Regional innovation is not an isolated event, but the rational allocation of manpower and other innovative elements, and it also requires mutual cooperation and active coordination between all innovation subjects. Enterprise is the important subject of technical innovation, any technical achievement only entered into the enterprise can result in social benefit; University and Research Institute are mainly responsible for the cultivation of talents, knowledge production, science and technology research, the innovation of scientific research management and participation in the transformation of achievements, they are the most important source of knowledge about innovation of enterprise activities, and without them, innovation will not last long; The government is the founders of regional innovation, which can directly and effectively control innovation activity, but it needs to change its functions, provide better services and conditions to other subjects, create a good environment for

the development of innovation, and guarantee the regional innovation activities in an orderly manner; Science and technology intermediary service organizations are not directly involved in the regional innovation system of value creation and implementation, but are the bridge of technological innovation between the supply and demand sides, and act as important medium to realize interactive of innovation elements. Intermediary organizations can provide an effective conversion and service platform for regional innovation resources, such as providing financing, evaluation and identification of achievement, talent market, technology platforms for the exchange of information and so on. If there is no intermediary organization, scientific and technological achievements will be greatly reduced. Therefore, for a complete and effective regional innovation system, every subject is indispensable, thus will form a great force to promote the development of regional innovation. This is demonstrated by the regional innovation network structure shown in Figure 1.

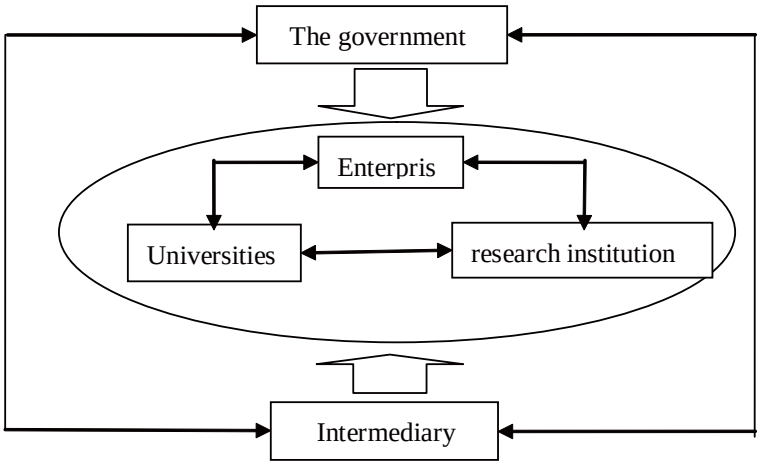

Figure 1
The Relationship Between Regional Innovation Subjects

1. RELATED RESEARCHES

The research on regional innovation subjects can be traced back to when Freeman presented the regional innovation system in 1987, and also in 1992, when Professor Cooke from the University of Cardiff wrote an article based on Freeman's lecture, titled "Regional Innovation Systems: Competitive Regulation in the New Europe". In this paper, he conduct more thorough research on the regional innovation system, arguing that regional innovation is based on the difference between regional resources and the environment of innovation activities (Freeman, 1991; Cooke, 1992). Since then scholars at home and abroad have done research on regional innovation from different angles: LI and ZHAO (2007) pointed out the government is regional innovation rules maker, subject coordinator, service providers and internal booster, plays the primary role in regional innovation, but noted that geographical influence the role of local governments and their ability to foster regional innovation (LI & ZHAO, 2007); HUANG and ZOU think that regional innovation is the result of many subjects involved in the process, is a process of socialization through the article informatization, which requires socialization encouraged by regional innovation system and government behavior (HUANG & ZOU, 2002); JIANG and NIU put forward the idea that regional innovation requires the introduction of relatively independent and fair" third people", stating that the government is the most suitable person by nature of condition, and that through the participation of government we can better guarantee the implementation of public policy by the article: the role of government in the regional innovation network (JIANG & NIU, 2005); ZOU consider the government in the undeveloped area of area must to build regional innovation subjects frame, to achieve the initial target by the regulation of enterprise, University and research institutions, intermediary regulation in the article: Discuss the Structure characteristics of regional innovation subjects of the undeveloped area (ZOU, 2006); ZENG and BAO dispute that regional innovation ability not only depends on the innovation ability of every subjects, but also closely relates to the flow and configuration of creative elements between each innovation subject by the article: discuss on the subjects and capability of regional innovation (ZENG & BAO, 2008); ZHAO, LI, and Wu (2009) hold the view that colleges and universities, research institutes and enterprises can effectively achieve regional innovation strategy in the innovation and regional innovation system by sharing the resources and rational division of labor, and also that the supporting role of government

and intermediary through the research on connection mechanism between innovation subjects and regional innovation system (ZHAO, *et al.*, 2009).

In a word, most of the related studies on regional innovation subjects are qualitative research. Therefore this article will establish a series of indexes reflecting the activities of innovation subjects, evaluate the functions and effects of innovation subjects of each province through the analysis of these indexes, and provide some guidance from the angle of coordinating the subject for area innovation (Cantner, Meder, & Wal, 2010). But in qualitative research, combined the existing literature, we can divide the regional mode into four classes:

Table 1
Regional Innovation Mode and its Characteristics

Mode	Characteristics
Enterprise leading type	The enterprise is central and is the industry development leader, the subject of innovation input and application. Innovation achievement tends to solve practical problems in production; the function of the government is service.
Government leading type	The ability of enterprises, universities and research institutions innovation is not strong. The government is in the core position, so if it wants to promote the development of regional innovation, the government must create conditions and guide innovation activities.
R&D leading type	The strength of science and technology is powerful, importance is attached to the culture of science and technology is preliminary form. At this point, research institutions and universities have become the source of innovation, leading the regional innovation activities.
Market dominant type (collaborative innovation type)	This kind regional has outstanding technological strength, rich in resources of science and technology, and innovation subjects enthusiasm are fully respect with a clear division of labor, high efficiency in innovation.

2. INDEX SELECTIONS

In order to make the evaluation more reasonable, we should first make all the functions and activities specific. For the government and intermediary organizations part, the state should supply good environment with regional innovation subjects, the government support traffic, capital, manpower, material resources as well as the education and high technology industry. The role of intermediary organizations is mainly to work as a bridge for technological innovation of universities, research organizations and enterprise, including the establishment of an information base for the transfer of technology and technical needs, and staff training about technical services, to provide a good financial environment and prepare advisory services for other subjects (Tiffin & Kunc, 2011). As shown in Figure 2:

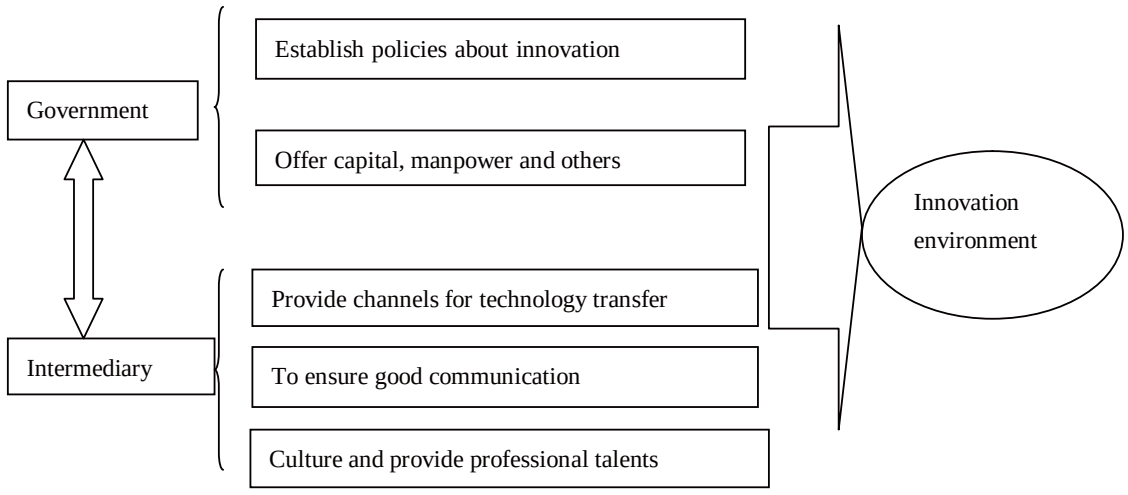

Figure 2
The Function of Government and the Science and Technology Intermediary Organization in Regional Innovation

Because specific numerical data for science and technology intermediary organizations are difficult to obtain, this essay will attempt a quantitative study on effects of the government in regional innovation. In order to demonstrate our findings, we selected indexes: X_1 as research and development expenditure (million Yuan), X_2 as R & D staff full time equivalent (person year), X_3 as financial support for science and technology (billion

Yuan), X_4 as education expenditure (million Yuan); we selected high-tech industry as the representative industry for the industry support of government, and took X_7 as total production value (billion) as a specific measure; Because there are many differences between each province, in order to eliminate the effects of provinces area, we choose X_5 as the highway line density (km/million square kilometers) and X_6 as railway line density (km/million square kilometers) as indicators.

Enterprise is the most important subject of technology innovation, because any innovation achievements can only generate practical significance when it closely linked with the market, and enterprise is the best link. Enterprise is the core subject of independent innovation; it can have its own patents and intellectual property rights as well as its own scientific research achievements through their own investment funds for scientific research and scientific research personnel or establish their own lab. For the university and research institutions, they are the source of regional innovation, and are a training base for talent of innovation, and the manufacturers and providers of innovation achievement. Colleges and universities provide innovative resources for other innovation subjects by talents education, cooperation with the enterprise, government and research institutions, optimizing the allocation of innovation resources, and strengthening the innovation achievement transformation. Scientific research institutions with strong technical strength and advanced equipment characteristics can cooperate with universities, while provide technical support for enterprises and the government (Etzkowitz & Leydesdorff, 2000). Specific situations are shown in Figure 3.

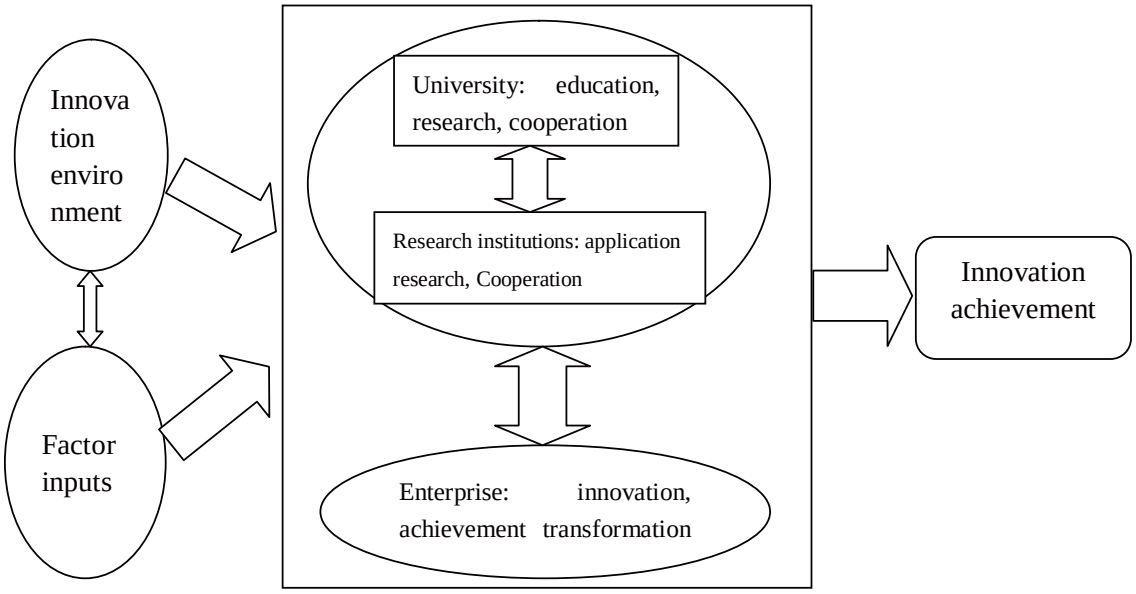

Figure 3
The Framework of Colleges and Universities, Scientific Research Institutes, Enterprises and Cooperative Innovation in Regional Innovation

Because universities and research institutions belong to the primitive innovation subject, therefore the research of these two will be focused on the ability of original innovation, such as input of manpower, material resources and finances. The research of the enterprise will focus on quantitative analysis of independent innovation and relationship with scientific research institutions and universities. The main indexes for universities are: X_1 as the number of schools of this region (a), X_2 as the number of humans who do research in higher education (a), X_3 as items in Higher school (a), X_4 as the number of people participating in international cooperation (a), X_5 as the number of people participating in international conferences (a), X_6 as The number of national and provincial awards (a), X_7 as The number of patents (item), X_8 as the value of contracts signed with enterprise (thousand); The evaluation index for the scientific research institution: X_1 as the number of Regional research institutions (a), X_2 as R & D personnel in research institutions (person), X_3 as R & D expenditure in research institutions (million Yuan), X_4 as research issue in institutions (item), X_5 as scientific papers from research institutions (paper), X_6 as the number of patent applications in research institutions (a), X_7 as form the national or industrial standards by research institutions; We take large and medium-sized enterprises as the most effective and mature power in enterprise research and development activities, so we selected indicators: X_1 as the number of large and medium-sized enterprises with R & D activities (a), X_2 as R & D person in Large and medium-sized enterprises, X_3 as research and development expenditure (million Yuan), X_4 as R & D project, X_5 as sales of new products X5 (ten thousand

Yuan), X_6 as Patent number (item), X_7 as the expenditure of introduction foreign technology (ten thousand Yuan).

3. EMPIRICAL ANALYSES

3.1 Empirical Model

The principal component analysis is comprised of multivariate statistical methods mainly about dimension reduction which can changes multiple indicators into a few independent and contains most of the information (80% - 85%) of the original index by the research of internal structure of indicators. Its advantage is getting the internal relations based on data analysis, determining the weights without the influence of subjective factors. The main components are independent of each other, to reduce overlap of information, the results is objectivity and accuracy.

Step 1: Acquisition of raw data, standardized

If one thing involving p index, the p-dimensional random vector $\mathbf{X} = (X_1, ..., X_n)$ to represent it, then the matrix of n samples is $\begin{pmatrix} X_{11} & \cdots & X_{1p} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & X_{np} \end{pmatrix}$, using the formula $Z_{ij} = \dfrac{X_{ij} - \dfrac{1}{n}\sum_{i=1}^{n} X_{ij}}{S_j}$ where i = 1,2, ... n ; j = 1, 2 ... p; $s_j^2 = \dfrac{\sum_{i=1}^{n}(X_{ij} - \bar{X}_j)^2}{n-1}$ to standardize the sample matrix, then we get Standardized matrix $(Z_{ij})_{n \times p}$

Step 2: Calculate coefficient matrix of matrix correlation $(Z_{ij})_{n \times p}$

Calculation of the correlation coefficient between the standardization sample every two indicators obtained the correlation matrix $R = (r_{ij})$.

Step 3: Calculate the Eigenvalues and eigenvectors

According to the characteristic equation $|R-\lambda I| = 0$, we calculate the characteristic roots, and arrange the characteristic roots in decreasing order: The eigenvector calculated as follows: u_1, u_2, $u_3 ... u_n$, so that we can get the main ingredients: $F = UX$, namely:

$$U = \begin{pmatrix} u_{11} & \cdots & u_{1p} \\ \vdots & \ddots & \vdots \\ u_{n1} & \cdots & u_{np} \end{pmatrix}$$

Step 4: Determine the number of principal components.

Usually we choose m to make the cumulative contribution rate $\dfrac{\sum_{i=1}^{m}\lambda_i}{\sum_{i=1}^{p}\lambda_i} \geq 85\%$, so it can achieve the purpose of dimensions reduction, also retain most of the original information.

Step 5: Find out the evaluation function.

$F = a_1F_1 + a_2F_2 + ... + a_mF_m$, the F_i is the score of i-th principal component $a_i = \dfrac{\lambda_i}{\sum_{i=1}^{m}\lambda_i}$ =1,2,…,m

3.2 Analysis

Since some data from 2010 and 2011 as well as Tibet's data are difficult to obtain, this article analyzes data from 2009 except Tibet. It takes data from China Statistical Yearbook, science and technology statistics in Chinese higher schools as well as the Regional Bureau of Statistics website.

First, government data analysis:

Table 2
Total Variance Explained

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	cumulative %	Total	Variance%	Cumulative %
1	4.90	69.99	69.99	4.90	69.99	69.99
2	1.23	17.55	87.54	1.22	17.55	87.54
3	.39	5.57	93.11			
4	.22	3.18	96.29			
5	.14	2.03	98.32			
6	.09	1.37	99.69			
7	.02	.31	100.00			

According to the analysis, the cumulative variance contribution rate of the common factor should reach 85% or more appropriate, so we have chosen two common factors, representing 69.99% and 17.55% of the original information. The two common factors represent a total of 87.54% of the information, and are sufficient to provide the information on behalf of the raw data.

Table 3
Component Matrix

	Component	
	1	2
X_1	0.952	-0.030
X_2	0.967	-0.175
X_3	0.900	0.105
X_4	0.860	-0.368
X_5	0.441	0.859
X_6	0.457	0.845
X_7	0.867	-0.355

We can conclude from the above table: the first principal component Y_1 is soft environment provided by the government. The second principal component Y_2 is hard environment provided by the Government, then:

$Y_1 = 0.952X_1 + 0.967X_2 + 0.9X_3 + 0.86X_4 + 0.441X_5 + 0.457X_6 + 0.867X_7$

$Y_2 = – 0.030X_1 – 0.175X_2 + 0.105X_3 – 0.368X_4 + 0.859X_5 + 0.845X_6 – 0.355X_7$

By the value of Y_1 and Y_2, a comprehensive evaluation of government activities at this time $Y = 0.69994Y_1 + 0.17548Y_2$, obtained the following Table 4:

Table 4
Provincial Governments Score Table

Province	Y_1	Y_2	Y	Rank
Beijing	10592670	-1949898	7072065	4
Tianjin	3529156	-810378	2327992	18
Hebei	6145653	-2098629	3933321	10
Shanxi	3682257	-1250348	2357948	17
Neimenggu	2775460	-984539	1769889	25
Liaoning	6416172	-1841705	4167753	9
Jilin	3149510	-1026085	2024411	23
Heilongjiang	4005922	-1285620	2578304	15
shanghai	8320242	-1910748	5488372	6
Jiangsu	15533765	-3917693	10185226	2
Zhejiang	10839630	-3077833	7046992	5
Anhui	5127248	-1655260	3298301	13
Fujian	4707830	-1480562	3035390	14
Jiangxi	3625358	-1248241	2318492	19
Shandong	11780587	-3025120	7714856	3
Henan	7403504	-2470938	4748408	8
Hubei	6012713	-1734317	3904200	11
Hunan	5884509	-1913846	3782961	12
Guangdong	16539240	-4534117	10780829	1
Guangxi	3469985	-1294961	2201542	20
Hainan	860730.7	-339195	542937.8	29
Chongqing	3086465	-998201	1985176	24
Sichuan	7785977	-2496324	5011662	7
Guizhou	2597867	-1000228	1642831	26
Yunnan	3321113	-1269881	2101741	22
Shaanxi	3356599	-1407103	2102499	21
Gansu	3812556	-908535	2509131	16
Qinghai	882485.5	-235012	576447	28
Ningxia	715031.3	-260081	454840	30
Xinjiang	2371689	-928576	1497093	27

Similarly, in accordance with the principle of the analysis of the government data, we analyze the colleges and universities, research and corporate institutions. Since the variance contribution rate of one factor is more than 85%, the results can be easily calculated and put the data in one table, you can draw the following results:

Table 5
Score Table of Every Subject in Province

Province	Y_G	Rank	Y_U	Rank	Y_R	Rank	Y_E	Rank
Beijing	7072065	4	823790.5	1	3270536	1	20129119	9
Tianjin	2327992	18	321801.1	20	186262.5	14	26579151	7
Hebei	3933321	10	271705.4	16	234591.7	8	11564714	17
Shanxi	2357948	17	249950	23	100588.2	20	6523361	20
Neimeng	1769889	25	150051.3	24	56788.61	25	3466682	23
Liaoning	4167753	9	127037.2	7	321918.4	7	24704654	8
Jilin	2024411	23	124714.3	13	174801.6	15	27454403	6
Heilongjiang	2578304	15	119333.2	17	213069.3	10	5413814	21
shanghai	5488372	6	113035.7	4	882829.8	4	51623257	4
Jiangsu	10185226	2	100898.8	2	653758.7	5	75311803	2
Zhejiang	7046992	5	89796.68	8	134889.6	17	46071129	5
Anhui	3298301	13	88677.28	6	211477.1	12	13120934	16
Fujian	3035390	14	86834.95	19	67379.4	23	15786759	15

To be continued

Continued

Province	Y_G	Rank	Y_U	Rank	Y_R	Rank	Y_E	Rank
Jiangxi	2318492	19	79856.15	12	78856.24	21	5139000	22
Shandong	7714856	3	76407.22	9	233887.1	9	70637655	3
Henan	4748408	8	68561.49	18	212662.2	11	17071393	13
Hubei	3904200	11	51876.01	15	409083.2	6	17128791	12
Hunan	3782961	12	42205.18	14	120957.3	19	18018602	10
Guangdong	10780829	1	40699.32	5	198879.4	13	81618966	1
Guangxi	2201542	20	29002	21	58749.1	24	7823802	18
Hainan	542937.8	29	23981.52	28	26208.81	28	115040	30
Chongqing	1985176	24	18141.3	10	70332.22	22	16974795	14
Sichuan	5011662	7	16320.75	11	911330.8	3	18006281	11
Guizhou	1642831	26	14566.13	26	40631.58	27	1900473	26
Yunnan	2101741	22	9926.328	22	135704	16	2405316	25
Shaanxi	2102499	21	7602.262	3	1001488	2	6685790	19
Gansu	2509131	16	5527.726	25	128344.8	18	2435072	24
Qinghai	576447	28	3151.891	30	11668.18	29	564304.3	29
Ningxia	454840	30	2958.94	29	5714.764	30	964305.2	28
Xinjiang	1497093	27	1493.758	27	44193.24	26	1056717	27

CONCLUSIONS

According to Table 5, we can see that:

(1) China's innovation performance presents a stepped distribution; the eastern part is significantly better than the central and western. All the subjects of every province are not the same, because of the geographical location, industrial structure and other influencing factors in the central and western regions. The function of the innovation subjects needs to enhanced to improve the regional innovation capacity of these area, requiring the coordination of all subjects. In most of central and western regions, Government leading type is appropriate; other subjects must do their best under the leadership of Government. So the purpose of this article will provide an ideas of how to analyze subjects, it will not analysis these areas more. Specifically, we choose Guangdong, Shanghai, Beijing and Jiangsu for example.

(2) Guangdong is an enterprise-led innovation under the government support. From the perspective of four subjects, the performance of Guangdong government and corporate is the highest in the country while the performance of universities and research institutions is in the fifth and thirteenth place. We did the qualitative analysis on science and technology intermediaries, there are 7000 Science and Technology Intermediary organizations in Guangdong, and more than 10 million people were employed, divided into three categories: technology venture service class, technological innovation service class, as well as comprehensive technology consulting services. These intermediary service organizations mostly established by the Government. Funds are mostly from the government too, the main problems are lack of funds, shortage of talent and information, weak service functions and problematic organizations. We can see that the science and technology intermediaries and other subjects in Guangdong have not yet formed a comprehensive collaborative model, and that future work is stimulate innovation enthusiasm of universities and research institutes, thus improving the service system of science and technology intermediary.

(3) From Table 5 we can see that Shanghai belongs to the comprehensive collaborative innovation model. The Government's performance is sixth, but enterprises, universities and research institutes are residing in fourth place, We can argue the functions of four subjects is effectively play. For science and technology intermediary organizations, the Shanghai Technology Exchange market system has been basically formed based on Shanghai United Assets and Equity Exchange, and plays an important role in technology, finance, human resources and information. Technical market transactions showing that transaction expanding, trading varieties broaden, trading volume increases, promoting the combination of technology and capital, high-tech achievements transformation and traditional industries. It accelerated the technology capitalization, investment diversification and the process of elements optimization play an active role in the development of Science and Technology in Shanghai. Shanghai will pay more attention to the original innovation and develop strategic emerging industries and people's livelihood industry under the premise of multi-agent collaborative innovation in future.

(4) Beijing belongs to the original innovation model led by the universities and research institutes. The performance of universities and research institutes in Beijing ranked first, government and corporate performance are only the fourth and ninth, so these two subjects limit the long-term development of scientific and technological innovation. For Science and technology intermediary organizations: Beijing already has about 10,000 scientific and technological intermediary agencies, more than 180 related associations, more than 500 professional services and more than 180,000 employees. There are more than 85 scientific and technological intermediary agencies whose service revenue of one year are more than 50 million Yuan. Ten agencies service have service revenue over 100 million, many well-known brand agencies such as ZhongKeQianFang Biotechnology Research Institute, Alliance PKU Management Consultants Ltd., Sinotrust, International Technology Transfer Center at Tsinghua University and horizon emerged in Beijing. This shows that the development of science and technology intermediaries can provides good conditions for the transfer of technological achievements transformation. Future work will focus on promoting the technology services work of Government and improve the enthusiasm of companies to join the regional collaborative innovation.

(5) Jiangsu is a fully integrated collaborative innovation model, similar to Shanghai. We know that Jiangsu ranked second in the performance of the government, enterprises and universities, and only the research institutions are listed fifth, but the strength of research institutions is still on the top of the nation. The science and technology intermediary service system in Jiangsu lead by Jiangsu Technology Property Exchange supplies a good opportunity for technological innovation, with nearly 1300 units engaged in scientific and technological services, employing 10 million labors. All of these conditions to provide good conditions for the technology market. Jiangsu got $30 billion technology contract turnover by signing nearly 20,000 technology contracts. Thus, Jiangsu is similar to Shanghai. It's a comprehensive and integrated collaborative innovation model, the main trend is to continue to promote the development of scientific research institutions, and make full use of regional advantages, strengthening inter-provincial cooperation, going from a small region towards large area.

In the phases of regional innovation and development, each subject has its own role and mechanisms. Due to the differences of regional economy, science and technology, natural resources, human, industrial structure and resource elements, the innovation model of every region is absolutely different. According to the analysis of performance of the subject in regional innovation, we get regional innovation mode for each every province based on existing qualitative research, point out the way to improve the efficiency of innovation activities and regional economic development direction.

LIMITATIONS

This article provides a quantitative method to analyze the behavior of subjects of regional innovation, the ideas is innovation. But for the data collection part, we cannot find the specific data of intermediary organizations of regional innovation, so the analysis of the innovation subject is not entire. Additionally we only selected the data of 2009, so we cannot fully understand the dynamic developing process of regional innovation system without adequate data. The future research can be combined the behavior of regional cooperative innovation and dynamic operation process together, then do quantitative analysis, perhaps this is a new research direction.

REFERENCES

Cantner, Uwe., Meder, Andreas,, & Wal, Anne. L. J. ter (2010). Innovator Networks and Regional Knowledge Base. *Technovation, 30*(9-10), 496-507. doi: 10.1016/j.technovation.2010.04.002

Cooke (1992). Regional Innovation Systems: Competitive Regulation in the New Europe. *Geoforum, 23*, 365-372.

Etzkowitz, Henry., & Leydesdorff, Loet (2000). The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations. *Research Policy, 29*, 109-123.

Freeman (1991). Networks of Innovation: A Synthesis of Research Issue. *Research Policy, 20*(5), 499-514.

HE, Xiaoqun (2008). *Multivariate Statistical Analysis*. Beijing: Press of Renmin University of China.

HUANG, Dong, & ZOU, Shangang (2002). Informatization Regional Innovation System and Government Behavior. *Technology and Education and Sustainable Development, 7*, 42-43.

JIANG, Minghui, & NIU, Xiaoshu (2005). The Role of Government in the Regional Innovation Network. *Learning and Exploration, 4*, 214-216.

KE, Huixin, & SHEN, Hao (2005). *Statistical Analysis of Survey Research*. Beijing: Press of Communication University of China.

LI, Xiaodi, & ZHAO, Yuting (2007). The Analysis of Behaviors of Local Government in the Regional Innovation System. *Industrial Technology and Economic*, 16-19.

MA, Guoyong (2010). Evaluation of Regional Innovation Networks: Based on Principal Component Analysis. *Canadian Social Science, 6*(2), 34-43.

Tiffin, S., & Kunc, M. (2011). Measuring the Roles Universities Play in Regional Innovation Systems: A Comparative Study Between Chilean and Canadian Natural Resource-Based Regions. *Science and Public Policy, 38*(1), 55-66.

ZENG, Xiaobin, & BAO, Yequn (2008). Discuss on the Subjects and Capability of Regional Innovation. *International Economics and Trade Research, 24*(6), 12-16.

ZHAO, Xicang, LI, Xiaoran, & WU, Jiying (2009). The Research on Connection Mechanism Between Innovation Subjects and Regional Innovation System. *Journal of Jiangsu University, 11*(2), 68-72.

ZOU, Zaijin (2006). Discuss the Structure Characteristics of Regional Innovation Subjects of the Undeveloped Area. *Regional Science and Technology Economy Social, 9*, 52-54.