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Evaluation of Regional Innovation Networks:

Based on Principal Component Analysis

EVALUATIONS SUR LES RÉSEAUX RÉGIONAUX D'INNOVATION:

BASÉES SUR L'ANALYSE DES COMPOSANTES PRINCIPALES

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Abstract: Regional Innovation Networks is becoming a main pattern in regional innovation and development. To figure out the characteristics of regional innovation networks, this paper is based on the sociology theory of networks relationship and structure analysis. It evaluates the whole situation of regional innovation networks of China and concludes that the degree of opening, the communication strength among the main innovation individuals within the region, the scale of the regional node, and so on, such kind of factors have great influences with the regional innovation networks. Above that, this paper also analyzes the reasons of existing problems and puts forward counterpart suggestions.
Keywords: regional innovation networks; relationship; structure; principle component analysis

Résumé: Les réseaux régionaux d'innovation deviennent un motif principal du développment de l'innovation et de l'économie régionales. Pour déterminer les propriétés structurales et relationnelles des réseaux régionaux d'innovation, cet article analyse les caractéristiques des réseaux régionaux d'innovation en utilisant les théories sociologiques sur les relations et les structures de réseaux. Il évalue le niveau global des réseaux régionaux d'innovation en utilisant les méthodes d'analyse des composantes principales et en conclu que le dégré d'ouverture, l'intensité d'échanges entre les sujets d'innovation dans les réseaux régionaux et l'ampleur de noeud régional ont une influence importante sur les réseaux régionaux d'innovation. Sur cette base, l'article analyse également les problèmes existants et en donne des propositions.
Mots-clés: réseaux régionaux d'innovation; relations; structures; analyse des composantes principales

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INTRODUCTION

Since J.A. Schumpeter put forward the concept of innovation, it has become one of the most focused topics in economics research. The research of innovation theory follows the pattern through Linear Mode to Non-linear Mode, and has become the theoretical and practical foundation of innovation networks theory.

Freeman C. published an article in Research Policy in 1991, and clearly mentioned the concept of innovation networks for the first time. Freeman uses the terms of Networks of Innovators, Innovation networks, and Networks of Innovation as the same meaning at the same time, and takes the innovation networks as one of a basic institutional arrangement. He concludes that the structures of the networks are mainly contributed by innovative cooperation among the enterprises and are aimed to improve the capability to increase sales and revenues (Freeman C., 1991). Since then, more and more scholars began to concern about innovation networks.

There are two main aspects to dig into innovation networks, one of which is the theory of innovation, and the other of which is the research on industry clusters. They are two counterpart levels of the innovation networks research, which are enterprises innovation networks and regional innovation networks (LI Jin-hua, 2009).

Up to now, scholars in or abroad have defined the concept of innovation from national innovation systems, innovation factors synergies, resources co-complements, industry clusters, and so on aspects, and have figured out some of the structures and characteristics of regional innovation networks.

It has been a main stream method to research regional innovation networks with social network analysis theory. Mitchell concludes in 1969 that people should take count of the scales, strictures, the interactive relationships and the process, and other factors to do network characteristic analysis. Granovetter defines one of the important characteristics, Strength, of the relationships in the networks in his famous paper The Strength of Weak Ties for the first time in 1973, and has made the beginning to concern about Relationships in network analysis.

After that, he brings in the concept of Embedded and defines between Relational Embedding and Structural Embedding in 1985. Burt puts forward Relationships and Locations as two basic vectors to figure the characteristics of networks innovation in 1982. Ben, Shaw-Ching Liu and the colleagues construct a mathematical model to characterize the relationships between network structures and innovation potentialities in 2005, and provide methods to the following empirical researches.

Based on all the results above, this paper uses the sociological networks analysis formula to figure out the regional innovation networks indicators and uses the practical statistics to do the empirical research, which has great theoretical and practical meanings.

1. ANALYSIS ON STRUCTURES AND RELATIONS OF REGIONAL INNOVATION NETWORKS

“Properties are characteristics of elements and the relationships in between, and they together decide the characteristics of the whole system.” (REN Sheng-gang, 2006). Take this from sociology aspects, regional innovation networks are characterized by the characteristics of the nodes and the inter-relationship in between the nodes of the networks. Therefore, regional innovation network analysis has two basic vectors of relations and structures. Lundvall and Sydow (1992) think that innovation network analysis is consist of two main parts that are elements and relations. Innovation networks are institutional arrangements within the region which are formed by inter-influences and inter-relationships between and among the inner-elements of the region. They have main innovation characteristics. In the networks, the generation, transmission, and infiltration of innovations are making effects in every node. They also emphasize that networks have great importance in transmitting explicit and implicit

knowledge within the regional innovation process (Fan Bo-nai, 2003).

Therefore, regional innovation networks could be defined as information exchanges, technology and knowledge transmission, and human resources and capital flows among enterprises, universities, institutions, intermediaries, and local governments within a certain region, which together form a relatively steady system. It can be clearly seen that, in the regional innovation networks, enterprises, universities, institutions, local governments, and training intermediaries are nodes of the networks, while information, technology, intellectuals, capital, and policies are connections of the nodes.

1.1 Structures of Regional Innovation Networks

Regional innovation networks consist of nodes and the connections. The basic nodes of regional innovation networks are the main bodies of the networks, including enterprises, universities and institutions, intermediaries, government, and so on. Among that enterprises are the core body of regional innovation. Through advantages complements within enterprises, the R&D cycle could be shortened; through information exchanges and trainings, the competitive strength of the enterprises could be well improved (LI Jin-hua, 2009). Universities and institutions are important source places of scientific achievements and innovations, which could provide the most advanced knowledge and technology, and could also provide innovative intellectuals. Intermediaries are the key nodes to connect enterprises and the other part of the networks, which could promote flows of the knowledge among. Governments are makers and executors of various public facilities and policies in certain regions, and are promoters of innovation activities. Therefore, the number, scale, and concentration of the main bodies within certain regions revise the innovation level. Limited by statistics, this paper takes the number of universities, the ratio of large and medium-sized industrial enterprises to total GDP within the region, and the ratio of GDP of principal city to total GDP within the region as the indicators to revise the main character of regional innovation situation.

The structures of regional innovation networks could be divided into inner-nodes, connections, and innovation environments. The main bodies share and exchange knowledge, technology and information in order to achieve their own goals. The structural holes' existing influences the movements of the knowledge and the transmission and share of the information. Thereby, limited by the statistics, this paper use the number of local career intermediaries to represent the indicators of regional innovation networks' structural holes. Meanwhile, as regional innovation networks are mostly localized, this paper uses the ratio of local enterprises GDP to total GDP of the region to revise the embedded factors of the networks. Regional innovation networks also have the openness factors. This paper uses local trade interdependency and total local imports and exports to represent the openness level of the networks.

1.2 Relations of Regional Innovation Networks

The characteristics of the relationships within the networks are the contents and pattern among the network main bodies, the strength of the relationships, the steadiness of the relationships and the direction of the relationships. Tang Fangcheng and the colleagues (2004) think that the interactive cooperation between and among the net nodes are far more important. The cooperation of the nodes connects each other and strengthens the attractiveness and cohesions of the network..

Gai Wenqi (2002) thinks that regional innovation networks are a sum of official and non-official relationships established by various actors, including enterprises, universities, institutions, local governments, so on organizations, and individuals. Aken and Weggeman (2000) define an Official Innovation Network as the innovation established on the contractual arrangement. They nominate the Non-official Innovation Network as the innovation established beyond the contractual arrangement. This paper uses the number of connections between and among heterogeneous nodes to represent the characteristics of regional innovation network communication situations. Therefore, this paper chooses the statistics of two indicators, Capital From Enterprises to Universities, and Deals on Technology Markets, to do the evaluation.

2. EMPIRICAL ANALYSIS

2.1 Empirical Model

The designing logic of principle component analysis is to calculate the covariance matrix of the practical observed values, and abstract every principle component successively by the largest contribution to variance, in order that it can select, concentrate and extract variables in the end(ZHANG Wen-xiu, 2001). The detailed steps are as follows: let primitive factors be **n** indicators as $\mathbf{x_1,x_2, \ldots,x_n}$, then convert them into new **m** factors as $\mathbf{E_1,E_2, \ldots,E_m}$, as below we get the equations.

$$E_1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n$$

$$E_2 = a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n$$

$$E_m = a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n$$

The square sums of coefficients in every equation are constantly equal to 1. New factors are linearly independent from each other. Besides, the successively formed primitive factor linear combinations are arrayed from small to large by the variance contributions. By this way, the new factors are successively become the first, second, and so on to the m^{th} principal components of the primitive factors. The number of the principal components is decided by accumulated variance contributions exceeding 90%.

2.2 Variables and Samples

This paper takes X1 as local universities, X2 as GDP ratio of principal cities to whole province, X3 as local career intermediaries, X4 as local goods trade values, X5 as foreign trade interdependency, X6 as financial flow from enterprises to universities, and X7 as volume of deals in technology market to indicate regional innovation network situations. Use SPSS to normalize the statistics as Table 1.

Table 1: 2008 China Regional Innovation Networks Indicators Normalized Statistics

Table 1-a

Region s	Universities	GDP Ratios Of Principle Cities to the Whole Province	Career Intermediaries	ocal Goods rade Values
Beijing	0.32633	-0.2009	-0.62897	1.25295
Tianjin	-0.4895	-0.2009	-1.14235	-0.01515
Hebei	0.87022	-0.2344	1.19056	-0.29344
Shanxi	-0.1087	-0.2329	-1.01484	-0.45271
Neimenggu	-0.9246	-0.2346	-0.07014	-0.48901
Liaoning	0.84303	-0.2298	0.76478	-0.06796
Jilin	-0.4895	-0.2253	0.59292	-0.45975
Heilongjiang	0.13597	-0.2275	-0.04131	-0.3948
Shanghai	-0.1903	5.12933	-0.78753	1.58681
Jiangsu	1.98519	-0.2364	2.90809	2.05228
Zhejiang	0.67986	-0.2324	1.40234	0.8515
Anhui	0.84303	-0.2339	1.10629	-0.41433
Fujian	0.21756	-0.23567	-0.16106	0.01416

To be continue…

Continued

Region s	Universities	GDP Ratios Of Principle Cities to the Whole Province	Career Intermediaries	ocal Goods rade Values
Jiangxi	0.24475	-0.23112	0.77698	-0.45786
Shandong	1.41411	-0.2375	0.93887	0.50197
Henan	0.57108	-0.2349	0.4266	-0.43226
Hubei	1.22375	-0.2273	-0.25198	-0.41087
Hunan	1.14216	-0.2306	-0.36508	-0.46496
Guangdong	1.41411	-0.2321	0.767	3.9926
Guangxi	-0.1359	-0.2340	-0.88954	-0.46039
Hainan	-1.5500	-0.2291	-1.0736	-0.51811
Chongqing	-0.70705	-0.2009	-0.83965	-0.48501
Sichuan	0.4623	-0.22885	0.39223	-0.40154
Guizhou	-0.76144	1.47721	-0.89065	-0.52582
Yunnan	-0.38072	-0.23075	0.62508	-0.48451
Xizang	-1.82203	-0.22695	-1.30645	-0.54305
Shannxi	0.40792	-0.22854	1.05751	-0.49292
Gansu	-0.92461	-0.2307	-0.39169	-0.50772
Qinghai	-1.74044	-0.22369	-0.98157	-0.54357
Ningxia	-1.57728	-0.22251	-1.02149	-0.53567
Xinjiang	-0.979	-0.23166	-1.09134	-0.40085

Table 1-b

Region s	Foreign Trade Inter-dependencies	Financial Flows from Enterprises to Universities	Volume of Deals inTechnology Market
Beijing	3.06188	3.14119	4.87234
Tianjin	1.09004	-0.22693	0.01299
Hebei	-0.4394	-0.37996	-0.34876
Shanxi	-0.4839	-0.68935	-0.36812
Neimenggu	-0.6216	-0.77561	-0.38569
Liaoning	0.00802	0.93385	0.08075
Jilin	-0.4838	-0.31373	-0.33318
Heilongjiang	-0.3784	0.09769	-0.22133
Shanghai	2.70564	2.06875	1.56056
Jiangsu	1.13291	1.87969	0.05128
Zhejiang	0.66945	0.63204	-0.13008
Anhui	-0.4541	-0.38417	-0.26664
Fujian	0.37349	-0.70258	-0.34164
Jiangxi	-0.4799	-0.55804	-0.39436
Shandong	-0.0340	-0.18151	-0.09344
Henan	-0.6513	-0.50606	-0.30303

To be continue…

Continued

Region s	Foreign Trade Inter-dependencies	Financial Flows from Enterprises to Universities	Volume of Deals inTechnology Market
Hubei	-0.5207	0.76795	-0.10953
Hunan	-0.6252	-0.07232	-0.18803
Guangdong	2.06254	0.08167	0.6072
Guangxi	-0.5179	-0.67035	-0.42052
Hainan	-0.3308	-0.86613	-0.41608
Chongqing	-0.51464	-0.39138	-0.11319
Sichuan	-0.52951	0.98022	-0.20958
Guizhou	-0.64235	-0.80951	-0.42395
Yunnan	-0.54209	-0.74958	-0.40836
Xizang	-0.50479		
Shannxi	-0.61173	0.85452	-0.20804
Gansu	-0.50705	-0.56676	-0.28075
Qinghai	-0.68602	-0.86831	-0.39467
Ningxia	-0.53804	-0.86426	-0.42987
Xinjiang	-0.00615	-0.86104	-0.39626

2.3 Empirical Analyzes

To do principal component analysis with SPSS this paper gets the characteristic roots, accumulated contributions, characteristic vectors and factor loading matrix and so on indicators.

Table 2: Characteristic Roots and Accumulated Contributions

Factors	Characteristic Roots	Variance Contributions %	Accumulated Contributions %
1	3.5077	50.1104	50.1104
2	1.8158	25.9399	76.0503
3	0.7345	10.4926	86.5429
4	0.5523	7.8901	94.4330
5	0.2403	3.4332	97.8662
6	0.0991	1.4152	99.2814
7	0.0503	0.7186	100.0000

To compare between characteristic roots and the accumulated contributions we can conclude the exceeding 90% standpoint. The 4 factors in Table 4 have an accumulated contribution as 94.4330%, which could comprehensively reveal information the whole indicators.

Table 3: Bartlett Spheroid Test

parameters	values
Chi-square values	149.2710
Freedom degree	21
Significance	0.0000

We can see from Bartlett Spheroid Test that the significance is 0, which is less than 0.5, thereby it is reliable to use principal component analysis to evaluate regional innovation networks situation.

At the same time, we get the factor loading matrix as Table 4:

Table 4: Factor Loading Matrix

Variables	Factor1	Factor 2	Factor 3	Factor 4
Local Universities	0.5691	0.7198	0.0721	0.1263
GDP Ratios of Principle Cities to the whole Province	0.3923	-0.5680	0.6861	0.2193
Career Intermediaries	0.3486	0.8562	0.1715	0.0851
Local Good Trade Values	0.8299	0.1087	0.1465	-0.5102
Foreign Trade Inter--dependency	0.9086	-0.2981	-0.0354	-0.2287
Financial Flow from Enterprises to Universities	0.8825	-0.0114	-0.1352	0.3904
Volume of Deals in Technology Market	0.7843	-0.3757	-0.4337	0.1264

According to factor loading matrix chart, we can get the factor model from the factor loading matrix as below:

$$X_1= 0.5691F_1+0.7198\ F_2+\ 0.0721F_3+0.1263F_4$$
$$X_2= 0.3923F_1\ -0.5680F_2+\ 0.6861F_3+0.2193F_4$$
$$X_3= 0.3486F_1+0.8562\ F_2+\ 0.1715F_3+0.0851F_4$$
$$X_4= 0.8299F_1+0.1087\ F_2+\ 0.1465F_3-0.5102F$$
$$X_5= 0.9086F_1-0.2981\ F_2-0.0354F_3-0.2287F$$
$$X_6=\ 0.8825F_1-0.0114\ F_2-0.1352F_3+0.3904F$$
$$X_7= 0.7843F_1-0.3757\ F_2-0.4337F_3+0.1264F_4$$

From the factor model we can see, local goods trade values, foreign trade interdependency, financial flow from enterprises to universities and the volume of deals in technology market are mainly affected by the first factor. Local universities, career intermediaries are mainly affected by the second factor. GDP ratio of principle city to the whole province is mainly affected by the third factor. The financial flow from enterprises to universities are mainly affected by the forth factor at some degree. Above that we can see that the degree of openness of the region, the strength of resource exchange within the regional innovative main bodies, and the scales of the nodes in the region have great importance to influence the regional innovation.

2.4 Empirical Conclusions

(1) According to the factor loading matrix, the factor model could be transformed as below:

$$F_1=0.5691X_1+0.3923X_2+0.3486X_3+0.8299X_4+0.9086X_5+0.8825X_6+0.7843X_7$$
$$F_2=0.7198X_1-0.5680X_2+0.8562X_3+0.1087X_4-0.2981X_5-0.0114X_6-0.3757X_7$$
$$F_3=0.0721X_1+0.6861X_2+0.1715X_3+0.1465X_4-0.0354X_5-0.1352X_6-0.4337X_7$$
$$F_4=0.1263X_1+0.2193X_2+0.0851X_3-0.5102X_4-0.2287X_5+0.3904X_6+0.1264X_7$$

By that, based on the existing statistics of China regional synthesis factor evaluations, we get Table 5 as below:

Table 5: China Regional Effectors Single Evaluation

	F1	F2	F3	F4
Beijing	10.301493	-2.821476	-2.681603	0.448909
Tianjin	0.023921	-1.543408	-0.382816	-0.530368
Hebei	-0.430588	2.011212	0.285271	0.216705
Shanxi	-2.213615	-0.572252	-0.134125	-0.127061
Neimenggu	-2.602413	-0.304536	-0.011378	-0.134608
Liaoning	1.487213	1.334736	-0.13794	0.52694
Jilin	-1.51369	0.503697	0.042688	0.119615
Heilongjiang	-0.783415	0.342365	-0.117079	0.259692
Shanghai	8.461106	-4.971708	2.551074	0.6081
Jiangsu	6.479111	3.906029	0.462342	-0.117723
Zhejiang	2.552992	1.753111	0.203337	-0.202794
Anhui	-0.521479	1.881003	0.217466	0.279731
Fujian	-0.570348	0.176994	0.053502	-0.445702
Jiangxi	-1.299696	1.217221	0.187728	0.122799
Shandong	1.1918651	2.0563511	0.2371891	-0.1248212
Henan	-1.248756	1.17464	0.116116	0.189162
Hubei	0.2950038	0.9317466	-0.2119705	0.6965863
Hunan	-0.735401	0.8444	-0.092285	0.389485
Guangdong	6.7116182	1.3918014	0.3116365	-2.2055683
Guangxi	-1.676388	0.959584	0.187914	0.036366
Hainan	-3.111155	-1.537507	-0.186913	-0.373904
Chongqing	-2.07583	-0.972125	-0.285767	-0.004542
Sichuan	0.19414	0.977904	-0.139009	0.722187
Guizhou	-2.227748	-1.849505	1.044674	0.200299
Yunnan	-1.959303	0.667907	0.150857	-0.02105
Xizang	-2.485103	-2.210666	-0.5751	-0.001928
Shannxi	0.137143	1.531115	-0.020486	0.786351
Gansu	-2.359019	-0.657206	-0.149181	-0.080905
Qinghai	-3.5669	-1.663136	-0.212383	-0.307039
Ningxia	-3.376045	-1.612017	-0.197021	-0.325692
Xinjiang	-2.441637	-1.388437	-0.18389	-0.446909

(2) Calculating regional innovation network characteristic synthesis evaluation values, we get evaluation function as below:

F=50.1104/94.443*F1+25.9399/94.443*F2+10.4926/94.443*F3+7.8901/94.443*F4

Based on that we get China regional innovation network synthesis evaluations as the chart below:

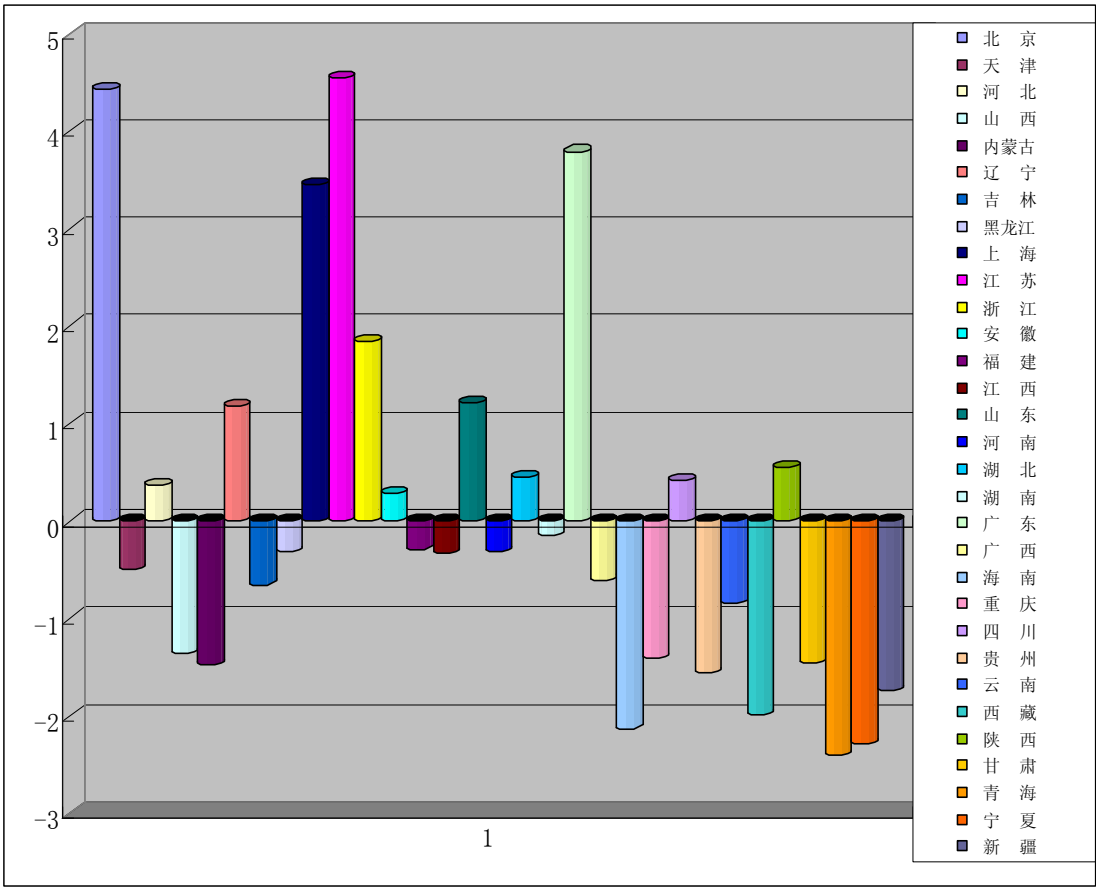

Chart Regional Innovation Networks Synthesis Evaluation

We can see from the chart above that regions below have relatively high levels of the regional innovation networks situation, which are Beijing, Shanghai, Guangdong, Zhejiang, Jiangsu, Shandong, and Liaoning. Hubei, Anhui, Sichuan, Hebei, and Shaanxi have a second level. The rest regions have a low level. Generally, Southeast Coast Regions have a comparably high level of regional innovative network situation, which is mainly because of that the concentration of universities and institutions are comparably high, the foreign trade are comparably frequent, and the inner-regional innovation has intimacy connections in the coastal regions. The Middle and West regions have generally low regional innovation capacities, which are related to their situations such as lack of financial support, less openness, lack of enthusiasms to communicate among the innovative main bodies within the region, and so on.

Therefore, in order to improve the regional innovation capacity of China, and to improve the whole innovative capacity of the country, this paper suggests as below:

(1) The government should increase the financial inputs to enhance the public innovation platform and the relative basic facilities; to enhance the solid environments of regional innovation networks; to perfect related policies to educe intellectuals; and to bring policies into play of the guidance. Meanwhile, the government should also enhance regional industrial technical systematical contribution strategies and carry out Cluster Innovation Strategies.

(2) Improve the level of connections between and among the nodes within the regions; increase the strengths of the information exchanges. Actively encourage the universities, institutions, and enterprises to cooperate and promote productions and researches at the same time. Meanwhile, they should try hard to improve the self-innovation capability of the universities and institutions.

(3) Strengthen the communication to outer parts from the region; actively promote the foreign

exchanges. Strengthen inner regional and foreign trade to exertion regional characteristics; introduce advanced technical and management experiences, new ideas to enhance the communication of knowledge.

REFERENCES

FAN Bo-nai. (2003). *Perspective through Urban Technological Innovation——A new aspect to analyze regional technology innovation* [M]. Beijing: Machinery Industry Press, 45

Freeman C.. (1991). Networks of innovation：a Synthesis of Research Issue[J]. *Research Policy, 20(5)*

LI Jin-hua.(2009). *Relationships between Structures and Knowledge Flows of Innovation Networks*. Economic Science Press, 27-32

LI Jin-hua. (2009). *Relationships between Structures and Knowledge Flows of Innovation Networks*. Economic Science Press, 31-32

TANG Fang-cheng, MA Jun, XI You-min. (2004). Coupling Mechanism of Harmony Management and the Related Complexity [J]. *Theory and Practice of System Project, (11)*

ZHANG Wen-xiu. (2001). *Rough Set Theory and Methodology* [M].Beijing: Science Press.