

REGIONAL INNOVATION SYSTEM: THEORETICAL APPROACH AND EMPIRICAL STUDY OF CHINA

LIU Shu-guang¹, CHEN Cai²

(1. School of Economics, Ocean University of China, Qingdao 266071, P. R. China; 2. College of Urban and Environmental Sciences, Northeast Normal University, Changchun 130024, P. R. China)

ABSTRACT Regional innovation system (RIS) is the new research field of modern economic geography in the age of knowledge economy. Based on the researches of regional economic geography, the authors of the paper consider RIS as the integrated and interactive systems with innovation milieu, elements, units, structure and functions. Five aspects of evaluation indicators including innovation input scale and output scale, innovation milieu transition, innovation inner operation, as well as innovation outer impact are worked out for final indicators of RIS scale and quality. According to different RIS situations, three patterns of independent, imitative and cooperative development are put forward for choosing. At the latter part of the paper, we select 12 provincial regions (including three municipalities and one autonomous region) of China for empirical study. The results show that there exists great difference among each region from the aspects of innovation scale and quality mainly owing to the diversification of RIS social and economic milieu, the major innovative units of enterprises, universities and R&D institutes. Finally, the paper points out the innovation development decisions for each region.

KEY WORDS: regional innovation system; theory; methods; cases of China

CLC number: F663

Document code: A

Article ID: 1002-0063(2003)03-0193-06

1 INTRODUCTION

COOKE *et al.* (1996) conducted a detailed survey on the concepts of regional innovation system (RIS) after the revolutionary study of FREEMAN (1987) and LUNDVALL (1992) on the national innovation system. COOKE pointed out that RIS is a group of geographically adjacent enterprises, R&D institutes and universities, which supports and produces innovation. WIIG and WOOD(1999) argued that the broad sense of RIS should also include the local governments and local services such as financial business institutes. Based on the review of RIS concepts and relative theoretical approaches, we can summarize the fundamental connotations as: 1) It has certain spatial spheres with open boundaries. 2) Enterprises, R&D institutes, universities, local governments and services are regarded as the major units of innovation. 3) Different innovation units connect each other through network-

ing and form RIS structure. 4) Innovation units produce and help produce innovation through self-organization and interactions with outer innovation context, therefore impact their own region and outer regions. 5) The innovation process continues through positive self-organization and inside-outside interactions. And it helps boost the regional sustainable development in the long run.

RIS theories began to be introduced into China at the late 1990s (WANG Ji-ci, 1998). And the Research Group of China Scientific & Technological Development Strategy (2002) did much works on provincial innovation capacities in their China Regional Innovation Capacity Report. The report consulted the theories of national innovation system of FREEMAN and the indicator systems of PORTER's USA Innovation Index. Based on the summary of the theoretical and methodological researches of the authors concerning RIS (CHEN and LIU, 1998a, 1998b, 1999; CHEN, 2001;

Received date: 2002-09-18

Foundation item: Under the auspices of the National Natural Science Foundation of China (No. 40131010)

LIU Shu-guang (1966–), male, a native of Xiajin County of Shandong, Ph. D., associate professor, specialized in regional economic development and regional innovation system. E-mail: dawnliu9631@263.net

LIU and CHEN, 1998, 1999; LIU 2002; LIU and XU, 2002), the paper conducts the RIS empirical study of selected provincial regions of China, and puts forward the innovation development decisions for each region.

2 APPROACHES TO RIS THEORY

According to the basic principles of regional economic geography, the situation of regional innovation system should be treated as the integrated economic territorial system. The regional innovation system can be perceived from 5 aspects of innovation milieu, elements, units, structure, and function.

2.1 Regional Innovation Milieu

The social, economic and natural factors were combined together to form the integrated milieu of regional innovation. Five aspects of factors as locations, environment qualities, GDP per capita, population quality and social progress are outlined in the study.

2.2 Regional Innovation Elements

RIS elements are regarded as the fundamental ingredients coming from the milieu. They help form the innovative units and participate the innovation process. The input of RIS elements is various and the input in R&D and talents is regarded as the most important.

2.3 Regional Innovation Units

The RIS units can be regarded as the relatively independent participants of regional innovation, and they have their special functions within the whole system. Five categories of innovative units are divided as: 1) enterprises, the units majoring in innovative product producing; 2) universities, the units mainly for innovative talents education and training; 3) independent R&D institutes, the units mainly for outputting innovative knowledge and technology; 4) local government, the unit mainly for regional innovation coordination and management; 5) services, the units serving other innovative units and the whole innovation system.

2.4 Regional Innovation Structure

The RIS structure is regarded as the steady integration of innovative units and their innovation-oriented

relationships. It can be perceived at two aspects of organizational structure and spatial structure. The major features of RIS structure include: 1) Degree of concentration. It is used to show the situation of special innovative units within the whole system in organizational structure analysis, and to show the situation of special innovative areas within the whole system in spatial analysis. 2) Degree of openness. It is used to show the situation of inward-outward innovation activities which stands for the degree of outer dependence of the innovation system. 3) Degree of connection. It is used to show the situation of relationship of innovative units within the system which stands for the degree of RIS self-organization. 4) Degree of hierarchy. It is used to show the relations of key innovative units and other units in organizational structure analysis, and the relations of core innovative area(s) and other areas in spatial structure analysis.

2.5 Regional Innovation Function

The RIS function can be considered to have impact on its environment and itself through the operation and the output of the system. The RIS function can be analyzed through two aspects: 1) the innovation scale, including the quantity of innovative products, patents, research papers, talents, etc.; 2) the outer impact on social progress and economic development.

3 APPLICATION METHODS

3.1 Establishment of Indicator System

Based on the RIS theory above, we work out the fundamental indicators for describing RIS situation. Concerning the feasibilities of actual data and their possibilities for comparison, the paper selects authoritative and easily found indicators for this study. The detailed indicators system is as following:

1 RIS milieu index

1.1 Location

1.1.1 Location attractions

1.1.2 Communication facilities

1.1.3 Location potentiality

1.1.4 Location quotient

1.2 Environment quality

1.2.1 Pollutant density

1.2.2 Carrying capacity per capita

1.2.3 Air pollution

1.3 Economic level

1.3.1 GDP per capita

1.4 Population quality

1.4.1 Education level

1.4.2 Science and technology capability

1.5 Social progress

1.5.1 Social civilization

1.5.2 Social security

1.5.3 Social development motivation

2 RIS element index

2.1 Talent input

2.1.1 R&D staff quantity

2.1.2 R&D staff/total population

2.2 Capital input

2.2.1 R&D capital expenditure

2.2.2 R&D capital expenditure/total expenditure

3 RIS unit index

3.1 Enterprises

3.1.1 Innovative production level

3.1.2 Innovation input-output ratio

3.2 Universities

3.2.1 Innovative talent training level

3.2.2 Innovation talent input-output ratio

3.3 Independent R&D institutes

3.3.1 Innovative knowledge & technology production level

3.3.2 Innovation knowledge & technology input-output ratio

3.4 Local government

3.4.1 Quality & efficiency of regional innovation coordination

3.5 Services

3.5.1 Scale of service industries

3.5.2 Services contribution to regional innovation

4 RIS structure index

4.1 Organization structure

4.1.1 Organizational centralization

4.1.2 Organizational openness

4.1.3 Organizational connection

4.1.4 Organizational hierarchy

4.2 Spatial structure

4.2.1 Spatial centralization

4.2.2 Spatial openness

4.2.3 Spatial connection

4.2.4 Spatial hierarchy

5 RIS function index

5.1 Innovation output

5.1.1 High-tech products export

5.1.2 Patents application

5.1.3 Scale of technology market

5.1.4 Publication of research papers

5.2 Innovation impact

5.2.1 Degree of science and economy integration

5.2.2 Economic growth

5.2.3 Environment protection

3.2 Establishment of Evaluation Model

The real situation of RIS can be described in 5 aspects of indexes. Through evaluation-oriented index integration, we work out also 5 aspects of indicators

for connecting basic data and final evaluation indicators as RIS scale and quality (Fig.1).

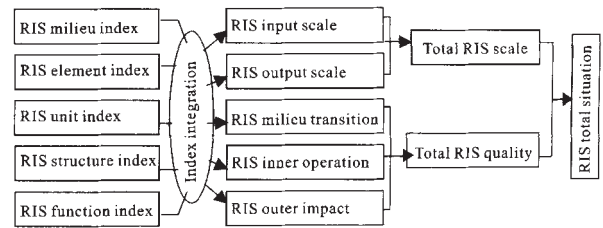


Fig. 1 Evaluation model of RIS situation

3.3 Choice of Innovation Development Pattern

According to the result of recent research (LIU and TIAN, 2001), there are at least three patterns for innovation development: 1) The first should be the independent innovation pattern, developed regions like the Silicon-valley of USA is the case in point. 2) The second should be imitative innovation model, developing regions like Japanese research parks in the 1980s can be regarded as the successful model. 3) The third should be the cooperative innovation model, a group of closely related regions with the same level like members of European Unions can be easily taken as the pattern of cooperative innovations. Different international patterns provide rich experiences for regional innovative development in China.

4 CASE STUDY OF CHINA

4.1 Selection of Study Regions

The paper chooses following regions as the subjects for the case study: 1) three municipalities of Beijing, Tianjin, and Shanghai; 2) three provinces in the eastern economic zone, Shandong, Zhejiang, and Guangdong; 3) three provinces in the middle economic zone, Jilin, Henan, and Hunan; 4) three provinces/regions in the western economic zone, Shaanxi, Xinjiang, and Yunnan.

4.2 Result of the Study

Table 1 shows the final result (score) of the RIS case study of selected regions in China. The order of the total RIS situation level is Beijing (87), Shanghai (67), Guangdong (48), Shandong (42), Tianjin (38), Shaanxi (38), Zhejiang (35), Henan (33), Hunan (31), Jilin (29), Yunnan (25) and Xinjiang (20). It is obvious that the three municipalities get the highest aver-

Table 1 Result (score) of RIS evaluation of selected regions in China

Selected regions	Scale of RIS input	Scale of RIS output	RIS milieu transition	RIS inner operation	RIS outer impact	Total RIS scale	Total RIS quality	Total RIS situation
Beijing	100	71	100	73	87	86	87	87
Tianjin	25	19	33	47	80	22	53	38
Shanghai	78	51	54	61	93	65	69	67
Shandong	51	54	10	37	45	53	31	42
Zhejiang	20	28	7	57	70	24	45	35
Guangdong	43	39	9	56	100	41	55	48
Jilin	21	16	15	43	56	19	38	29
Henan	35	26	8	29	64	31	34	33
Hunan	28	24	9	37	59	26	35	31
Shaanxi	46	28	29	37	51	37	39	38
Xinjiang	9	5	9	29	62	7	33	20
Yunnan	12	13	7	43	60	13	37	25

Sources: Chinese Academy of Sciences, 2001; Chinese Ministry of Science and Technology, 1998; The Research Group of China Scientific & Technological Development Strategy, 1999; 2000; 2001; The Research Group of Sustainable Development of Chinese Academy of Sciences, 1999; WANG Jian, 1998)

age mark (64); the regions in the eastern economic zones get the second (42); the regions in the middle economic zones get the third (31); while the western regions get the lowest mark (28).

4.3 Analysis of RIS Scale

The RIS scale analysis is divided into the input scale and the output scale. The main characters of the RIS input scale for selected regions can be summarized as follows (Fig.2). Beijing and Shanghai rank the top positions in the innovation input scale, while Tianjin only ranks the 8th. As for provincial regions, Shandong, Guangdong, and Shaanxi are outstanding in innovation input. Henan, Hunan and Jilin stand in the middle zone. Zhejiang, Yunnan and Xinjiang are in the lower positions.

As for the RIS output scale, Beijing and Shanghai rank the 1st and the 3rd respectively, while Tianjin gets down to the 9th rank. Shandong (2nd) and Guangdong (4th) are outstanding in the innovation output. Shaanxi, Zhejiang, Henan and Hunan stand in the middle. Tianjin, Jilin and Yunnan are relatively lower. And Xinjiang is at the bottom.

The features of RIS input and output scale show that there is obvious differentiation between metropolitan cities and provincial regions, and also the gradient diversification from east to west among provincial regions. But there are also some exceptional cases such as the relatively low innovation input & output level of Tianjin City, the low input level of Zhejiang Province in the eastern region, and high input level of Shaanxi Province in the western zone.

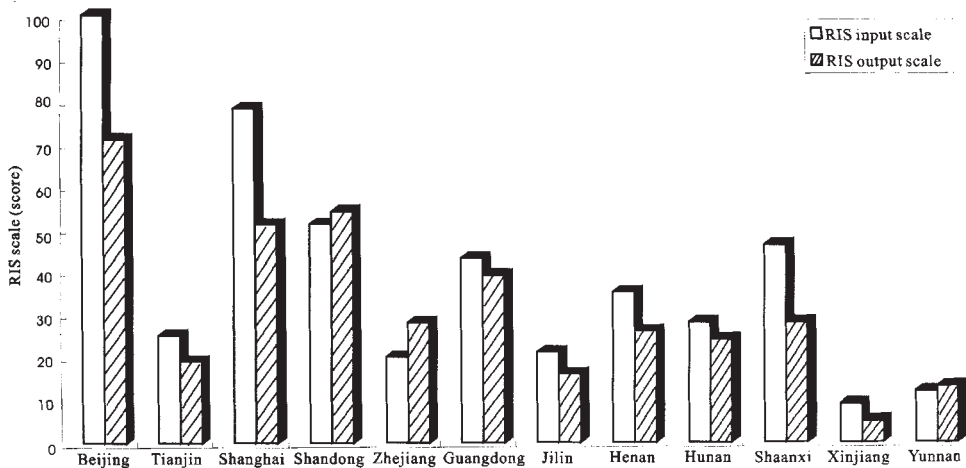


Fig. 2 Comparison of RIS scale of selected regions in China

4.4 Analysis of RIS Quality

Three aspects of RIS milieu transition, input-output

ratio, and outer impact are applied for the RIS quality analysis (Fig. 3). 1) From the two RIS transition indexes of R&D expenditure/GDP and R&D staff/ total

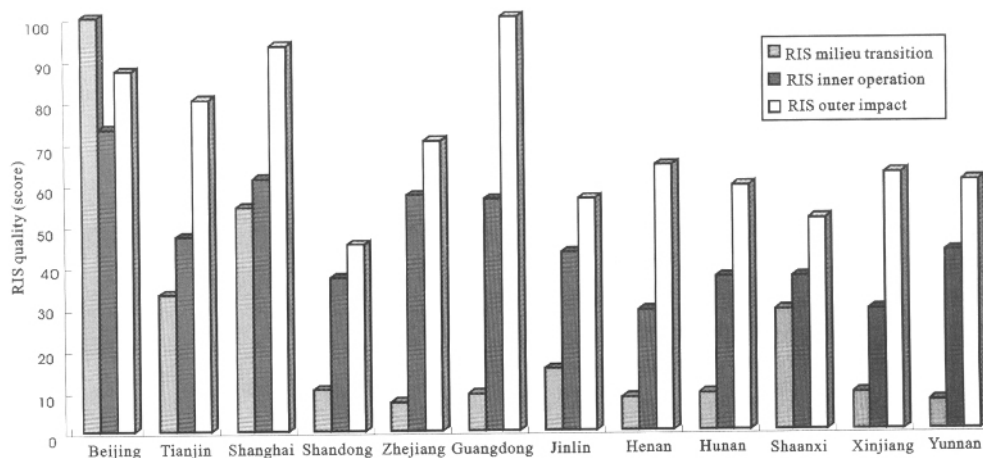


Fig. 3 Comparison of RIS quality of selected regions in China

population, Beijing, Shanghai and Tianjin have better economic and talent basis for supporting regional innovation in the whole country. Jilin and Shaanxi have better innovation support basis in provincial regions. 2) Innovation input-output ratio of innovative units including enterprises, universities, R&D institutes, local government, and services forms the RIS innovation ratio index. The first 5 regions of this index include Beijing, Shanghai, Zhejiang, Guangdong and Tianjin. Jilin, Yunnan, Shandong, Hunan and Shaanxi are in the middle. Henan and Xinjiang are at the bottom. 3) The indicator of science & economy integration is used to stand for the whole RIS outer impact index in this study. The first 5 regions of this index are Guangdong, Shanghai, Beijing, Tianjin and Zhejiang. Henan, Xinjiang, Yunnan, Hunan and Jilin are in the middle. Shaanxi and Shandong are at the bottom.

The features of RIS quality show that the metropolitan cities are better than provincial regions, and most of eastern zones have higher quality than western ones. But Shaanxi Province suffers from low innovation efficiency even if it has good innovation basis. The three aspects of RIS quality index are unsatisfied compared with its RIS scale. But Zhejiang should be the opposite case with high RIS quality based on its small RIS input scale.

5 REGIONAL INNOVATION COUNTERMEASURES

(1) Beijing should insist in cooperative development with advanced countries/regions. Through learning the experiences of highly innovative regions, Beijing should be built into a national innovation center with international competitiveness.

(2) Shanghai and Guangdong should reinforce their innovation through international cooperation and increase the innovation elements exchange with other domestic regions.

(3) Tianjin has been making steady progress in regional innovation, but its fundamental innovation capability is relatively low. Tianjin should pay attention to the interregional cooperation with highly innovative regions like Beijing.

(4) Zhejiang and Jilin have some superiority in innovative talents and technology. But the enterprise innovation capability is relatively low in Jilin Province. It should pay more attention to its innovative products development based on its competitive fundamental researches. Zhejiang shows its strong product innovation capability mainly through its small and medium-sized enterprises, and it should keep closer relations with R&D institutes for reinforcing basic innovation.

(5) Shaanxi takes on great tasks of western development of China, and its fundamental innovation advantages should be considered to connect with international cooperation and assist with innovation support services.

(6) The low innovation quality of Shandong does not match with its large innovation scale. How to motivate the innovation forces of different units, and develop innovation support services under the context of international competition, are the major problems of the province.

(7) Just like their locations of the middle zone, the innovation situations of Henan and Hunan also stand in the middle. Therefore their problems of regional innovation development will have some significance standing for the majority of China's regions. Multidimensional cooperation with other regions is necessary

for their steady innovation process.

(8) The frontier locations of Xinjiang and Yunnan from their superiority of attracting others in the age of knowledge-economy. Under the favorable national policies of western development, their unique location and abundant natural and cultural resources will help form the basis for their taking-off through establishing strategic alliances with domestic and foreign partners.

6 CONCLUSIONS

The theoretical and empirical researches of the paper show that the RIS can be perceived as the integrated system with following characters: 1) its operation depends greatly on the key innovative elements (especially the talents and capital) coming from its milieu; 2) the innovative units, particularly the enterprises, R&D institutes and universities, act as the main innovators through their input-output activities; 3) the RIS quality has low interrelations with the RIS scale, especially the input scale. This illustrates that the RIS self-organization level is more important.

The results approximately reflect the real situations of China's provincial regions, and the characters of regional innovations are also vindicated through recent documents of relative studies. But the sources of data are limited and some indicators could not completely convey the meaning of the theory, therefore there is the deviation in the case study.

The regional innovation patterns are diversified owing to sophisticated regional and historical conditions, which are difficult to be changed into indexes for exact RIS evaluation. The decisions of regional innovation for each region should be carefully analyzed through in-depth interview and trajectory analyses. The RIS situation evaluation model in this paper could not provide all answers for regional innovation. RIS process indicator system is needed for complete RIS situation & development study.

REFERENCES

- CHEN Cai, 2001. *Regional Economic Geography* [M]. Beijing: Science Press, 118–179. (in Chinese)
- CHEN Cai, LIU Shu-guang, 1998a. Construction of theoretical system of regional economic geography in the 21st century in China[J]. *Scientia Geographica Sinica*, 18(5): 393–400. (in Chinese)
- CHEN Cai, LIU Shu-guang, 1998b. A retrospect and prospect on the development of regional economic geography [J]. *Progress in Geography*, 17(3): 1–10. (in Chinese)
- CHEN Cai, LIU Shu-guang, 1999. An initial approach to the construction of methodology in regional economic geography[J]. *Geographical Research*, 18(1): 1–6. (in Chinese)
- Chinese Academy of Sciences, 2001. *High Technology Development Report of China*[M]. Beijing: Science Press, 155–163. (in Chinese)
- Chinese Ministry of Science and Technology, 1998. *China Science and Technology Indicators* [M]. Beijing: Social Science Document Press, 171–222. (in Chinese)
- COOKE P, BRACZYK H J, HEIDENREICH M (eds.), 1996. *Regional Innovation Systems: the Role of Governances in the Globalized World* [M]. London: UCL Press, 1–16.
- FREEMAN C, 1987. *Technology Policy and Economic Performance: Lessons from Japan*[M]. London: Pinter.
- LIU Shu-guang, 2002. An initial approach to future development of regional economic geography in China[J]. *Area Research and Development*, 21(2): 1–4. (in Chinese)
- LIU Shu-guang, CHEN Cai, 1998. Construction of regional economic geography: a study on conditions and elements of economic region[J]. *World Regional Studies*, 7(2): 1–7. (in Chinese)
- LIU Shu-guang, CHEN Cai, 1999. Progress of regional economic geography in China: a comparative study [J]. *The Journal of Chinese Geography*, 8(3): 257–263.
- LIU Shu-guang, TIAN Li-qin, 2001. Regional development through innovation: models and international cases[J]. *World Regional Studies*, 10(1): 20–23. (in Chinese)
- LIU Shu-guang, XU Shu-jian, 2002. Progress of regional innovation system studies: an international perspective[J]. *China Science and Technology Forum*, 11(5): 33–37. (in Chinese)
- LUNDVALL B A (ed.), 1992. *National Innovation System: Towards a Theory of Innovation and Interactive Learning* [M]. London: Pinter.
- The Research Group of China Scientific & Technological Development Strategy, 1999. *The Report of China Scientific & Technological Development*[M]. Beijing: Economy and Management Press, 140. (in Chinese)
- The Research Group of China Scientific & Technological Development Strategy, 2000. *The Report of China Scientific & Technological Development*[M]. Beijing: Social Science Document Press, 152–175. (in Chinese)
- The Research Group of China Scientific & Technological Development Strategy, 2001. *The Report of Regional Innovation Capacity of China*[M]. Beijing: The Press of Party Members' Training School of the Chinese Communist Party Central Committee, 567–683. (in Chinese)
- The Research Group of Sustainable Development of Chinese Academy of Sciences, 1999. *1999 Report of Sustainable Development of China*[M]. Beijing: Science Press, 295–372. (in Chinese)
- WANG Ji-ci, 1998. In search of innovativeness: the case of Zhongguancun[A]. In: MALECKI E, OINA P (eds.). *Making Connections: Technological Learning and Regional Economic Change*[C]. Aldershot: Ashgate, 205–220.
- WANG Jian, 1998. *Regions and Development*[M]. Hangzhou: Zhejiang People's Press, 281. (in Chinese)
- WIIG H, WOOD M, 1999. What comprises a regional innovation system?[R]. <http://web.sol.no/step>.