IIPS

Prepared for the IIPS Symposium on

Globalization and
Japan's Science and Technology Strategy

19 – 20 November 2007
Tokyo

Session 1
Monday, 19 November 2007

Comparative Study over
Innovative Region vs. Innovative Nation
China and Other Countries

Chen, Xiangdong
Beijing University of Aeronautics & Astronautics

Institute for International Policy Studies (IIPS) Conference 2007
Nov. 19-20, Tokyo, Japan

Comparative Study over Innovative Region vs. Innovative Nation

China and Other Countries

Professor Chen, Xiangdong
The School of Economics & Management
Beijing University of Aeronautics & Astronautics
Beijing, 100083
P. R. China

Introduction:

It is no doubt that the most determined source for generating sustainable economic progress lies in technology innovation and continual knowledge accumulation. Based on this crucial resource, national and regional technology capability as well as economic development can be continually running on a competitive base, therefore, strategic policy for effective technology development becomes key issue for both country level national innovation system (NIS) and for regional level innovation system (RIS). However, these two systems are different, and strategic policy consideration for technology capabilities is usually a more relevant topic on a national level, rather than in regional boundaries, in spite of social, cultural, and regional varieties (Archibugi, 2005). On the other hand, ownership based technology capability / innovation resources has been discussed actively along with National Innovation System in China as well as in other countries in recent years, together with international background of rapid pace of globalization in which technology innovation occurs almost without country boundaries. The key question here is how do we combine regional innovation movement in an international sense, with ownership based national innovation system as a key policy issue, in a rather national sense. This research paper, based on author's recent research work, focuses on relationships between regional innovation and national innovation, in order to provide implication for strategic policy purposes. The paper argues that regional innovation movement is fundamental and RIS is basic platform in composition of national innovation system, while ownership based technology innovation policy is playing a vitally important role only in complementary cases where market failure may exist.

II Regional innovation vs. National Innovation system: related Concepts.

It should be noted that regional innovation system and NIS are in common in many important characters, such as knowledge generation and knowledge diffusion process. According to Archibugi and Coco (2005), technology side of national innovation capability can be summarized as following three parts, which can also characterize important nature in regional innovation movement:

(a) Embodied/Disembodied, since it is recognized that technological capabilities are embodied in capital goods, equipment, infrastructures, and in disembodied forms such as human skills and scientific and technical expertise, and both types of capability contribute vitally to the technological base of a country

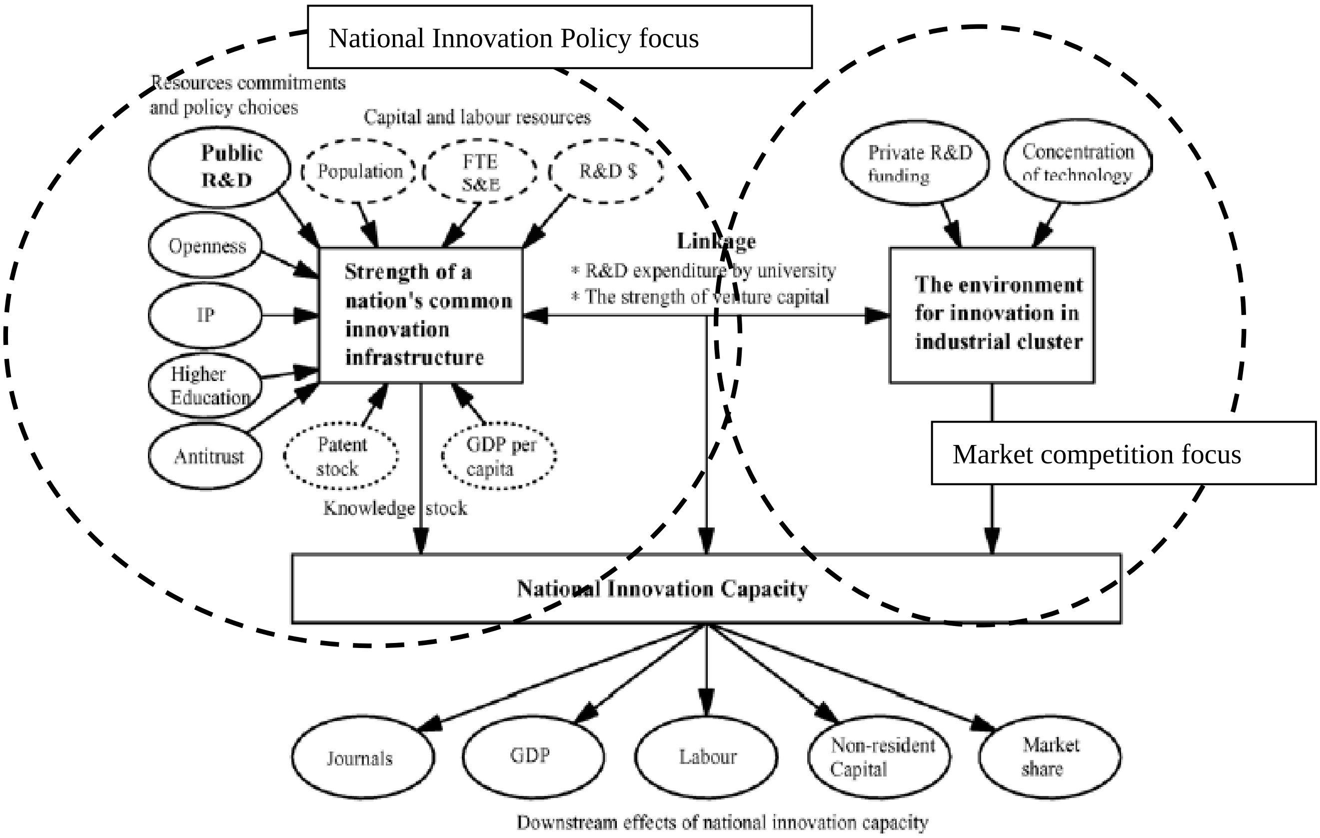
(b) Codified/Tacit, As codified component of knowledge is usually represented by manuals, blueprints, patents, and scientific publications are as important as the tacit components associated with learning by doing and by using (Lundvall and Johnson, 1994).

(c) Generation/Diffusion. As it has been long recognized that both the production of knowledge
and its diffusion and imitation provide a valuable technological resource for the country and the region concerned.

The three parts of movement can actually cover development of technology based resources both in regional and national level in three stages, namely, dynamic part as new knowledge production and diffusion (described in C), technology transfer part as a knowledge formation process (described in B), and technology accumulation part as knowledge integration (described in A).

However, there are policy sides of innovation systems, and the concepts of both NIS and RIS in strategic policy terms focuses on different phenomena, which may further imply important policy differences.

Major components and related activities related to national level system usually include development factors on both market competitive resources and resources which may encounter market failure. Thus an appropriate framework of National Innovation System or national technology capability system can be shown as follows (*Furma, Porter, Stern,* FSM model, 2002):



Based on this model, it can be summarized that Regional Innovation System (RIS) is different from NIS in following three aspects:

1. National Innovation System (NIS) is a policy oriented nation-wide commitment and an action system with more strategic planning for the whole country, which may cover typical concerns as follows:
   a) Government – University – Industry collaboration and relationships focused;
   b) Start-Ups and high tech enterpreneourial companies focused
   c) Key industrial sector development oriented;
   d) Key product / media component focused;
   e) Energy / Environmental sustainable technology focused;
   f) National security focused;
   g) Overseas company competition concerned.

   Therefore, NIS is a system of action primarily from government of particular countries, vision oriented, strategies focused, and international political and economical relation backed;
2. Regional Innovation System (RIS) is a primarily local market driven network, clustering based and technology accumulation with technical traditions in local industries, generated and developed through market competition and market selection, combined with local innovation resources including local government policies which can only have limited impact under market mechanism.
3. Externalities are usually effective only in bounded regions. Although access to international technology and knowledge flows is especially important for developing countries, as Romer (1986); Lucas (1988), Grossman and Helpman (1991) argue, that externalities such as knowledge spillovers or learning by doing

are the driving force for today's economic growth in a long run, however, such learning by doing activities and tacit type innovation are usually bounded in particular region, and externalities do have geographic limits, external knowledge and technology transfer can be effective usually within certain regions and serve as important vehicle for regional economic growth. With such kind of evidence that knowledge spillovers are geographically localized (Jaffe et al., 1993; Branstetter, 2001), some further implications can be drawn as important reference on regional innovation.

(1) Regions with a larger agglomeration of firms grow faster because regional concentration of firms facilitates knowledge spillovers.
(2) Foreign trade and FDI policy are more regional bounded, which provide important source for technology spillovers;
(3) High tech policy is usually localized as high tech sectors need important support from local resources, such as higher education facilities, qualified human resource, technology accumulation from certain traditional sectors, and market preference, as well as local purchasing power.

It can be concluded that RIS is a platform for NIS and therefore innovation activities in regional level is fundamental to national innovation performance on the whole.

However, differences between NIS and RIS can vary from country to country. It can be sharply significant in some countries (mainly latecomers or developing countries such as in China), also can be modestly marked or even faded in some other countries (typically in European countries).

In order to clarify differences and relationships between RIS and NIS, this paper provide following chart to combine different type of innovation activities and provide concept of two kinds of policy, namely, Ownership Oriented Policy and Lead Market Oriented Policy.

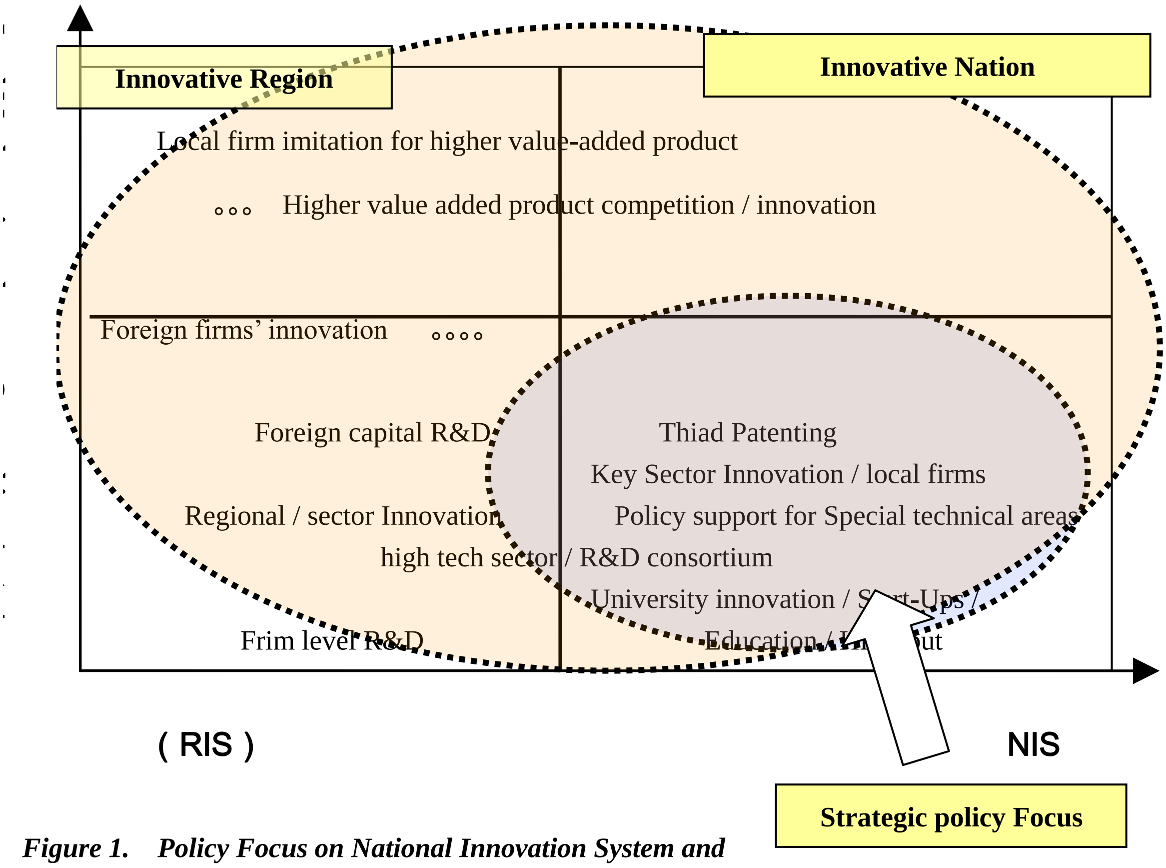


Figure 1. ***Policy Focus on National Innovation System and Regional Innovation system***

The differences in two kinds of policies can be further described through following five issues.

(1) NIS is established based on regional innovation platform, in which innovation activities are clustering from various kinds of sources including overseas, thus Lead Market Orientation policy is the most important in defining promising regional market.

(2) NIS related strategic policy is primarily ownership oriented, indicating important positioning for certain type of technology as well as particular sectors in which market mechanism can not fully apply.

(3) Ownership Oriented policy / strategy is fundamental for both local firms and for the nation as a whole that owns capabilities competing in national and international market; however, Lead Market Oriented policy is equally important in that the market in innovative region is usually functioned as clustering to host high tech firms as well as high tech itself.

(4) Lead Market Oriented policy is primarily regional and is fundamental for innovative region as well as for innovative nation, which accept various kinds of collaborations, while ownership based national innovation movement accept collaboration with policy limitations.

(5) Innovative nation and innovative region can be evaluated according to appropriate indicator system, reflecting ownership innovation performance of the nation in the former case and reflecting activeness of innovation in regions in the later case.

Finally, it should be further noted that Lead Market indicates, according to Bartlett and Ghoshal (1990), a geographical location, where the market is created by local demand and nature resource embedded. The Lead Market Oriented policy emphasizes places with the first adoption of new designs and techniques rather than the place to host first invention. Thus the related region can be considered as a kind of multinational corporation that host a globalized product (Raffée and Kreutzer, 1989), and of cause still retain possibility to host both (including first invention). Moreover, under Lead Market framework, collaboration space can be further developed and extended. Following chart shows space and possible positioning of different policy system.

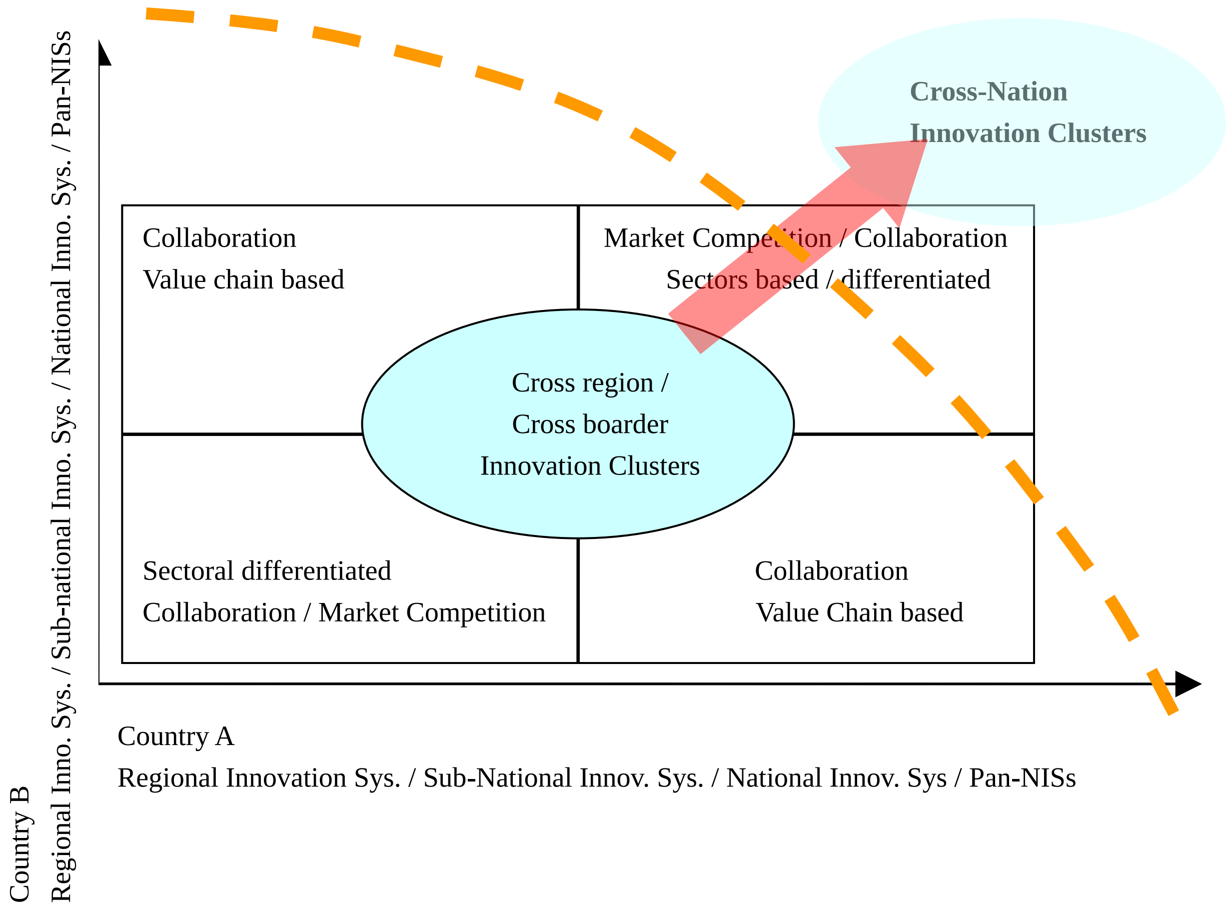


Figure 2. Collaboration Space under Different Innovation Policy in Two Countries A & B

Under this framework, other two special innovation systems can be further suggested, Sub-National Innovation System between Regional Innovation System and National Innovation System, and the other, Pan-National Innovation Systems which are widely extended over different NISs.. Sub-NIS is a Clustering based innovation system which emphasizes innovation networking and clustering, while the Pan-NISs indicates collaboration in a wider scope across borders but on the country level. Clearly, both NIS and Pan-NIS’s can be heavily strategic issue.

III. China's Case on Regional Technology Innovation, in Comparison with Policy Support.

This paper now turns to regional innovation issues, particularly on un-evenly distribution of innovation resources and innovation performances, which can provide important implications for policy studies.

(1) Regional Innovation in China: Input and Outcome

This paper will use R&D input data and patent data as major indicators for policy oriented innovation performance.

Patent system is one of effective way to protect technical inventions, and patent can be used not only as an indicator for innovation outcome, but also as a kind of resources for further innovation in production place. Apparently, patent data have weakness as only about 50% of patent can be adopted in real production (Guellec and Van Pottelsberghe,1999), on the other hand, not all manufacturing companies are willing to patent their new designs. Therefore, values of patent protection for innovation output can vary from industry to industry. However, patent data are still acceptable for most policy researchers regarding to innovation activities, especially when considering those inventions that can bring gains through upgrading productivity（Acs et al 2002)**.**

High tech export data are also taken into consideration in this paper, however, it should be noted that Foreign Direct Investment (FDI) firms play very important role in high tech sectors in China, almost dominating high tech export from China.

Figure 1 contrasts typical economic performance in each region in China with overall R&D input and government based science and technology financial input, in a relative terms (R&D ratio to local gross regional production, R&D / GRP; and local government S&T financial input to all input from local government). It is very clear that innovation input develops partially in parallel with economic performance, however, there are exceptions in several typical regions.

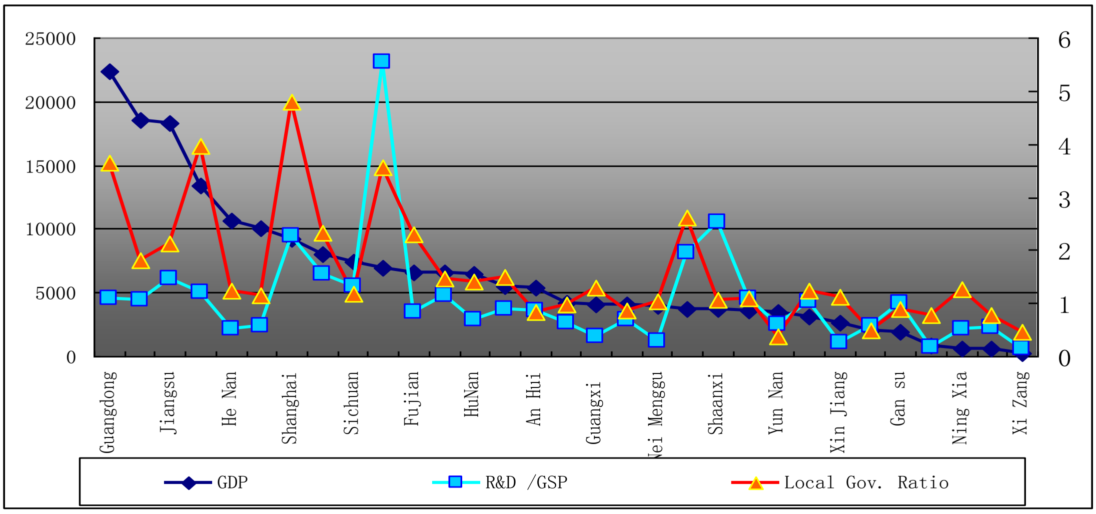


Figure 1. Comparison of Regional Economic Development and Innovation Input (2005)

Source: edited based on China Science & Technology Statistic Year Book, 2006

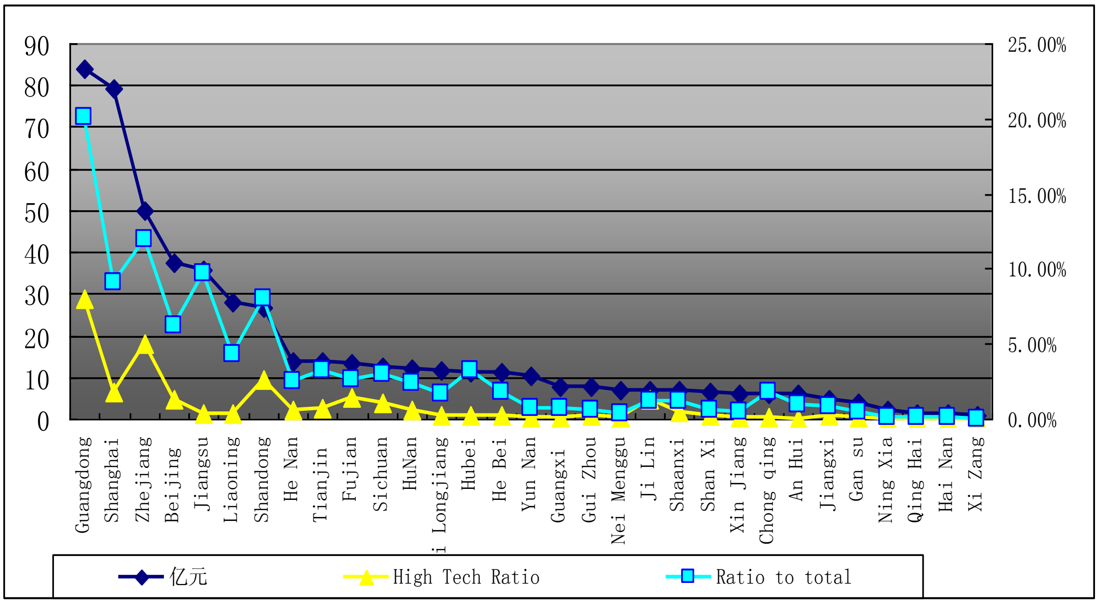


Figure 2. Comparison of Regional Innovation Input and High Tech Output

(patent share and high tech export share, 2005)

Source: edited based on China Science & Technology Statistic Year Book, 2006

Figure 2, on the other hand, indicates how effective local innovation input is correlated to economic performance in high tech sectors. All regions in China are ranked by R&D input value (0.1 billion RMB, 2005), with comparison of regional output in patent (patenting share to national total in 2005) and in high tech product export (share of export value to national total)

It can be summarized that innovation performance is independent in certain important regions, not in parallel with economic development, while the innovation output in terms of patenting records and high tech export shares follows similar pattern, as Figure 1 shown, with levels of innovation input in Chinese regions, however, the innovation output in different regions: namely patent share and high tech export share, provide the most closely correlated pattern, which may suggest that innovation in most regions in China are driven by market forces, primarily in foreign capital dominated high tech sectors.

(2) Regional Innovation in China: Innovation Performance through Multiple Indicator Analysis

In order to investigate through multiple characters, this paper also adopts Principle Component Analysis (PCA) methodology on following seven different indicators over 31 Chinese geographical regions. Two principle components are achieved, representing primarily on market driving forces (F1) and Policy driving forces (F2). Correlation parameters among the seven indicators and extracted principle components are listed below for further reference.

Table 1. Principle Components on Typical Innovation Indicators (2005)

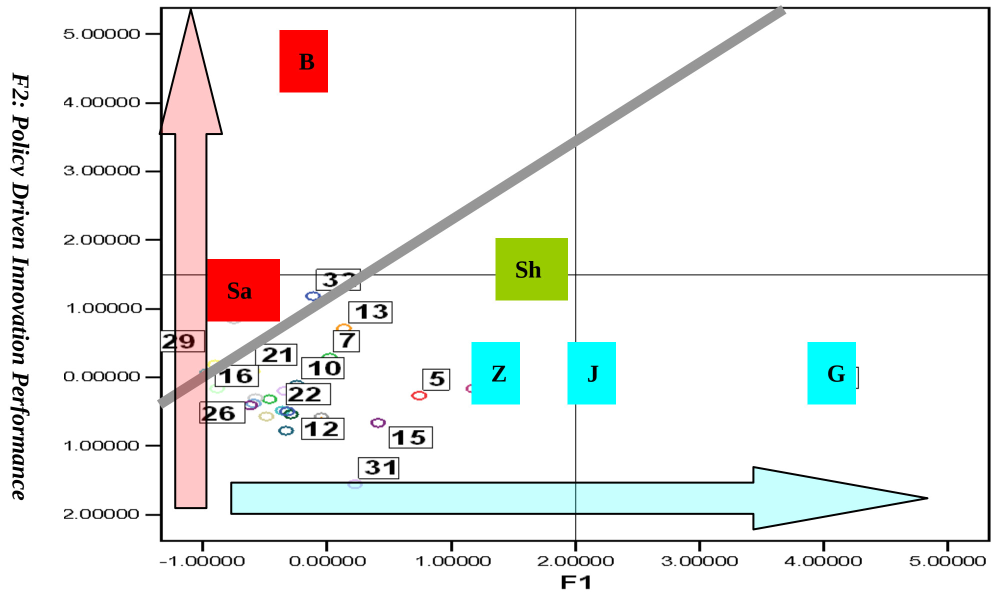
Items	Component	
	F1: Component I	F2: Component II
Local Government Techn Development Support Ratio	**.583**	**.559**
R&F / GRP	.126	**.943**
Invention Patent Ratio	-.383	**.687**
Ratio of Transaction Volume of Local Technology Market	.311	**.845**
High Tech Firm Ratio	**.942**	.137
High Tech Export Ratio	**.917**	.154
Patenting Ratio	**.932**	.220

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a Rotation converged in 3 iterations.

A two-dimensioned chart can be achieved based on values of each region along these two principle measures (refer to following Figure 3).

It can be clearly shown that some typical regions (in red) in China are mainly policy driven while others (in blue and green) are market driven, with Beijing and Guangdong as two representative in two extremes.



F1: Market Driven Innovation Performance

Figure 3. Principle Component Analysis, Regional Innovation Performance in China (2005)

Notice: B: Beijing; Sh: Shanghai; G: Guangdong; J: Jiangsu; Z: Zhejiang; Sa: Shaanxi province.

II. Dispersion of Innovation Performances: China's Case.

Un-evenly distribution of innovation activities is a common rule in technology transferring and technology diffusion process, especially among different countries and nations. It is usually considered that increased concentration of innovation is generated after industrial concentration, or clustering. Glaeser et. Al (1992) suggested that the increased concentration of a particular industrial sector within specific geographic region will facilitate knowledge spillovers across firms, thus to some extent create geographically bounded clustering and so called sub-national innovation can occur through geographically bounded networking.

Krugman（1994）states that the regional performance in economy and innovation does not always parallel with each other, rather it is less inequality in regional economy than in the regional innovative ability. Countries which cover larger geographic range and maintain higher level hierarchical clusters of industry production are more likely to show uneven distribution of innovative resources. Although there is close relation between regional economic development and innovation activities, inherent relative independent rule exist, which inject more research value to the study about how regional innovation activities differ with each other on the broader international level.

Empirical study on innovation based convergence test in this study include following parts:

***(1) . σ* Convergence:**

The convergence parameter indicates degree of over time dispersion on innovation indicators across different geographical regions. There are numbers of typical measures to examine the σ Convergence, such as Coefficient of Variation， Herfindhal-Hirshman（HHI），Theil Index (TEC)，Entropy Index (GEI) etc.. This paper use Coefficient of Variation (CV):

$$\sigma_{rt} = \frac{\sqrt{\sum_{i=1}^{n_r}\left(p_{it} - \bar{p}_{rt}\right)^2}}{\bar{p}_{rt}} \qquad (1)$$

Where r indicates sample geographical district（r =1,2,3）, namely, Eastern China, Mid China, and Western China, i represents sample regions within certain country（i =1,2,… n_r）, $\bar{p}_{rt}$ stands for sample country r 's average number of patent application in duration t .

The empirical test on China' s case on σ Convergence over three geographical districts proves that CV in all three district as well as in national level increase over the investigation time duration window, which indicates that along with faster growth of local technology capability, un-evenness or dispersion level become more significant. Comparatively speaking, Western China district, although with the least innovation performance, is the strongest part in terms of dispersion of innovation activities, while Mid China district behaves as the most evenly distributed location on innovation performance.

On the other hand, CV level in different province is usually higher than level of dispersion on district level, intra-district dispersion is not the major explanatory factor for nation-wide dispersion, inter-district dispersion in fact has stronger impact.

(2) β convergence and Club Convergence hypothesis:

According to Barro，Sala-I-Martin (1992,2002) and Sala-I-Martin (1996) based on convergence hypothesis of neoclassic economic growth theory（Solow,1956；

Swan,1956） which indicates faster pace of regional economic growth if the region initiated with lower economic development level. This study applies regional patent data in China between 1996 and 2005, instead of GRP (Gross Regional Production) per capita, to related model to test the convergence level. By applying regional parameter X, estimation of β convergence can also prove if there is Club Convergence, meaning that within each of the three typical geographical districts in China, if there is a significant convergence among related regions in terms of innovation measurements. Following testing formula can be further applied to this purpose

$$\frac{\ln p_{i,T} - \ln p_{i,0}}{T} = \alpha + \beta \ln p_{i,0} + \phi X_{i,0} + \mu_i \qquad (2)$$

i represents sample region in China（i=1,2………31），T is end year (2005) of time window, while 0 indicates base year (1996), P_{iT} P_{i0} is patenting numbers in sample region i at end year and base year respectively. Club Convergence can be tested if β is less than 0, otherwise regions in a geographical district are rather diversified in terms of innovation performance.

Since β is achieved positive in this study, but not pass through test, the ***β*** convergence hypothesis cannot be supported. However, when a regional virtual variables is introduced, test on ***β*** is significant, which indicates that dispersion on innovation performance over the three geographical districts is much stronger than regional level dispersion.

(3) Gini coefficient

Gini Coefficient can also be applied to examine un-evenly distributed pattern over different

Geographical districts under according to certain innovation performances. The Gini Coefficient can reveal inter-district and intra-district differences, as well as levels of technology based convergence and related Club Convergence, usually with condition that intra-district Gini Coefficient decrease and inter-district Gini Coefficient increase.

Following formula applies when such conditions are satisfied:

$$G = G_I + G_N + R \qquad (3)$$

$$G_I = \sum_{r=1}^{K} w_r s_r G_r \qquad (4)$$

Where G represents patenting number in certain region within a district, which can be further classified into three parts: G_I for inter-district Gini Coefficient, G_N for inter-district Gini Coefficient among three major geographical districts, and R indicates cross effect between the two; K further represents total number of sample districts, w_r is share of region r to total numbers of regions in the country; and s_r is also share of r on patenting numbers to total level of the nation.

Gini Coefficient in this study reveals that nation-wide dispersion of innovation capacity in China comes mainly from inter-district dispersion movement on innovation sources, with larger contribution level (more than 60% for continuously 10 years). However, there is a tendency after 2002 that inter-district dispersion gradually less influential on overall national dispersion, which may imply that economic and technical support on Western China district helps local regions to upgrade technology level through adoption of technical hardware as well as capabilities of learning by doing.

Compared with economic performance dispersion over different district and regions in China, the Gini Coefficient in innovation terms indicates that there is higher degree of dispersion in innovation performance than in economic performances, however, the degree of such difference is rather modest.

After all, regional convergence study indicates that China does not hold robust prove for convergence hypothesis that backward region develops continually faster than advanced region in terms of innovation performance.. Both innovation wealthy region and less innovative region in China have a tendency increasing gaps among regions as well among districts in innovation terms. Policy on appropriate transfer of technology and advanced technical knowledge is still keen in the near future. .

Table 2 Dispersion Degree (Gini Coefficient) on Regional Innovation Performance (Patent) in China between 1996-2005

Year	Nation-wide Disp. Innovat.. perform	Typical Districts			Intra-Dist. Gini Coef.	Inter-Dist. Gini Coef.	Contribution of Intra-Dist.Dispers	Contribution of Inter-Dist.Dispers	Contribution of Cross Intra / Inter Dist.
		Eastern China	Mid China	Western China					
1996	0.4734	0.3172	0.2198	0.4478	0.1100	0.3279	23.24%	69.26%	7.49%
1997	0.4870	0.3398	0.2056	0.4289	0.1136	0.3433	23.32%	70.51%	6.17%
1998	0.4916	0.3419	0.2067	0.4243	0.1137	0.3489	23.13%	70.96%	5.91%
1999	0.5105	0.3579	0.2016	0.4326	0.1180	0.3636	23.11%	71.23%	5.66%
2000	0.5222	0.3478	0.2008	0.4244	0.1164	0.3795	22.29%	72.67%	5.04%
2001	0.5469	0.3674	0.2042	0.4484	0.1228	0.3980	22.45%	72.78%	4.76%
2002	0.5621	0.3656	0.1996	0.4644	0.1235	0.4162	21.98%	74.05%	3.97%
2003	0.5699	0.3707	0.2233	0.4956	0.1273	0.4169	22.33%	73.16%	4.51%
2004	0.5853	0.3859	0.2574	0.4915	0.1319	0.4290	22.53%	73.31%	4.16%
2005	0.6138	0.4167	0.3020	0.4963	0.1428	0.4448	23.26%	72.47%	4.27%

Table 3. Reference: Dispersion Degree (Gini Coefficient) on Regional Economic Performance (GDP) in China between 1996-2005

Year	Nation-wide Disp. Econom. Perform	Typical Districts			Intra-Dist Gini Coef.	Inter-Dist Gini Coef.	Contributioof Intra-Dis.Dis	Contributioof Inter-Dispers	Contribution of Cross Intra / Inter Dist.
		Eastern China	Mid China	Western China					
1996	0.4140	0.3218	0.1920	0.4470	0.1090	0.2379	26.34%	57.47%	16.20%
1997	0.4103	0.3182	0.1944	0.3984	0.1038	0.2551	25.29%	62.18%	12.54%
1998	0.4129	0.3151	0.1989	0.3913	0.1031	0.2604	24.96%	63.08%	11.95%
1999	0.4152	0.3121	0.2034	0.3833	0.1024	0.2659	24.67%	64.06%	11.27%
2000	0.4208	0.3139	0.2089	0.3805	0.1029	0.2728	24.45%	64.83%	10.71%
2001	0.4194	0.3137	0.1833	0.3673	0.1012	0.2801	24.13%	66.78%	9.10%
2002	0.4211	0.3146	0.1766	0.3661	0.1011	0.2832	24.00%	67.25%	8.75%
2003	0.4248	0.3199	0.1716	0.3605	0.1017	0.2876	23.95%	67.71%	8.34%
2004	0.4257	0.3241	0.1746	0.3627	0.1029	0.2860	24.16%	67.19%	8.65%
2005	0.4317	0.3317	0.1839	0.3656	0.1053	0.2885	24.38%	66.81%	8.80%

III. Dispersion of Innovation Performance: Comparative Study among the US, Japan, and China

The empirical part of this study aims to reflect dispersion degree among regions in typical countries, through analysis of indices of innovation activities. By selecting internationally adaptable indicators in China, the US, and Japan in the recent years, the study is using effective means to compare the distribution pattern of innovation activities in regional level.

This paper selects 51 states in the US, 47 provincial regions in Japan, and 31 provincial and cities in China, 129 sample regions in total over the three countries, investigating seven typical innovation performance indicators, in contrast to common economic performance measures

(1) Comparison of Regional Innovation Activities among the Three Countries: Regional Dispersion Level Analysis.

This paper applies a Regional Dispersion Coefficient Index (RDCI = standard deviation / average value of specific innovation indicator) to measure degree of concentration of regional innovation activities, and further compare the RDCI with typical economic performance indicators among corresponding region and countries. As dispersion coefficient is adjusted by the average value of innovation indicator of the sample regions in specific country, it can, to great extent, explain regional uneven distribution pattern in specific country. It is commonly recognized that the larger the dispersion coefficient, the more significant degree of uneven characteristic of innovation activities in the region.

Typical innovation performance indicators are selected (refer to Table 4) through China’s statistical yearbook as well as websites from the US and Japan, in contrast to typical economic indicator. As is widely accepted, Gross Regional Production (GRP) is an aggregate measure of the value of goods and services produced in corresponding region, indicating measure local production capacity, and thus a level of wealth, while GRP per capita provides a measure of qualitative local market, as higher GSP per capita will provide higher local demand for highly elastic and higher value added market.

Table 4: Typical innovation indicators

Fist-class index	Second-class index	Description
Innovation Input	Total R&D expenditure	Absolute value, representing volume of innovation input
	R&D personnel	
	Government granted fund / R&D expenditure	Relative value, representing innovation density in terms R&D input
	R&D / GRP	
Innovation Output	Inventive patent granted	Indicators for regional innovation output
Innovative Environment	Number of local universities	Regional innovation environment in terms of potentiality of innovation resource

The value of RDCI for each of innovation indicators among China, the US, and Japan is presented in Figure 4. It can be shown that the US is holding the highest RDCI score on most innovative indicators, except on patent record on which Japan positions the highest dispersion. RDCI level for indicator in all three countries exceeds regional dispersion coefficient on GDP per capita, which proves Krugman's statement (1994) in particular. In China's case, dispersion in economic performance is significantly higher than that in other two countries, while dispersions in innovation are in the lowest place in most indicators among the three, which addresses the biggest difference from other two developed countries.

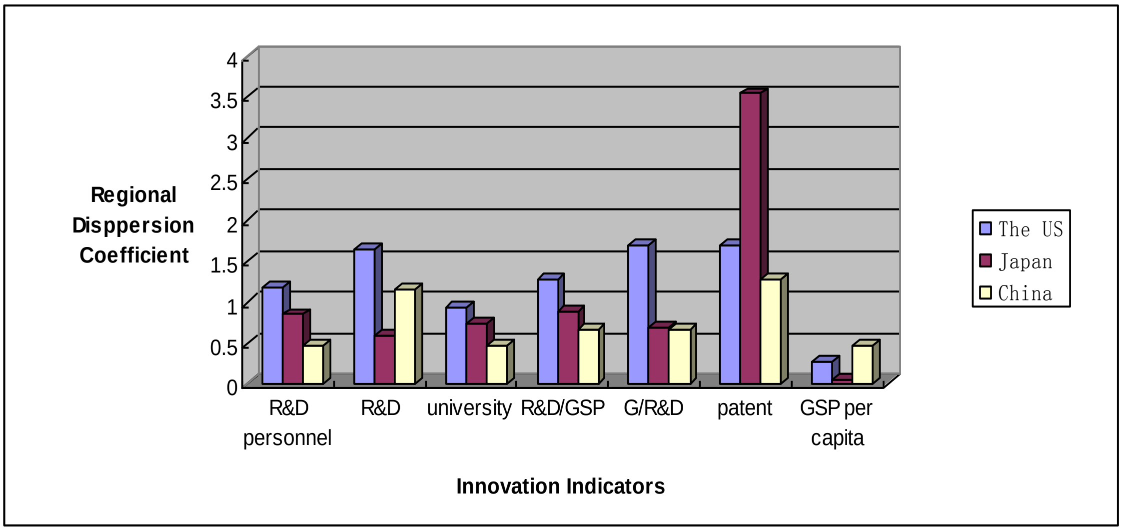


Table 4. Comparison of Dispersion Level on Typical Innovation Performance in Contrast to Dispersion of Economic Performance among the US, Japan, and China.

Source: edited based on data from China Science & Technology Statistic Year Book, 2006, China bureau of statistics, http://www.jpo.go.jp, http://www.census.gov

Based on theoretical findings from Glaeser et. al (1992) and Krugman (1994), facts reflected in this study that geographical dispersion of innovation performance is a more common case in developed nations, it could be further concluded that local policy support for geographically bounded innovation should be selective and should be well harmonized in terms of sector difference with other regions, and to some extent highly relate to local market and resource backed endowment factors, rather than one size policy for whole nation. On the other hand, regional economic performance in terms of typical income indicators such as GDP per capita, should be more evenly distributed, which may be benefit from more effective innovation output and cross region transfer of both tangibles and intangibles in a more economic way.

(2) Comparison of Regional Innovation Activities among the Three Countries: Market Driven vs. Policy Driven

This study also applies Principle Component Analysis (PCA) method to this three-country analysis in order to find difference in regional innovation activities among total 129 regions in three countries.

Through KMO and Bartlett Test (KMO value: 0.628 and significant probability of Bartlett is less than 1％), six innovation indicators are proved eligible for FCA process. All indicators are standardized for the analysis. Table 5 provides correlation between original indicators and the two principle components extracted, with 80% of accumulated variance contribution over total variation, which indicates that the two principle components containing enough information from original performance measures.

Table 5. Correlation between principle component and original indicators

Typical Innovation Indicators	***Principle Component***	
	The 1st principle component Composite Innovation Indicator (F1)	***The 2nd principle component Innovation Intensity (F2)***
Number of Universities	***0.886***	*-0.199*
Number of Patent	***0.817***	*-0.076*
R&D personnel	***0.789***	*-0.047*
Total R&D expenditure	***0.721***	*0.083*
Government / R&D	*-0.035*	***0.991***
R&D/GRP	*-0.062*	***0.986***

Based on these correlations, first principle component (F1) can be considered as geographical composite indicators of innovation in absolute value, including innovation environment (university numbers), innovation input (R&D expenditure, R&D personnel), and typical innovation output (numbers of invention patent granted), while the second principle component (F2) mainly refers to proportional measures on policy oriented nature and innovation intensity indicators, such as R&D/GRP、government granted fund to total R&D.

A two-dimensional chart (Figure 5) can also be produced based on these two principle components to reveal distribution of 129 regions in three countries regarding innovation performance.

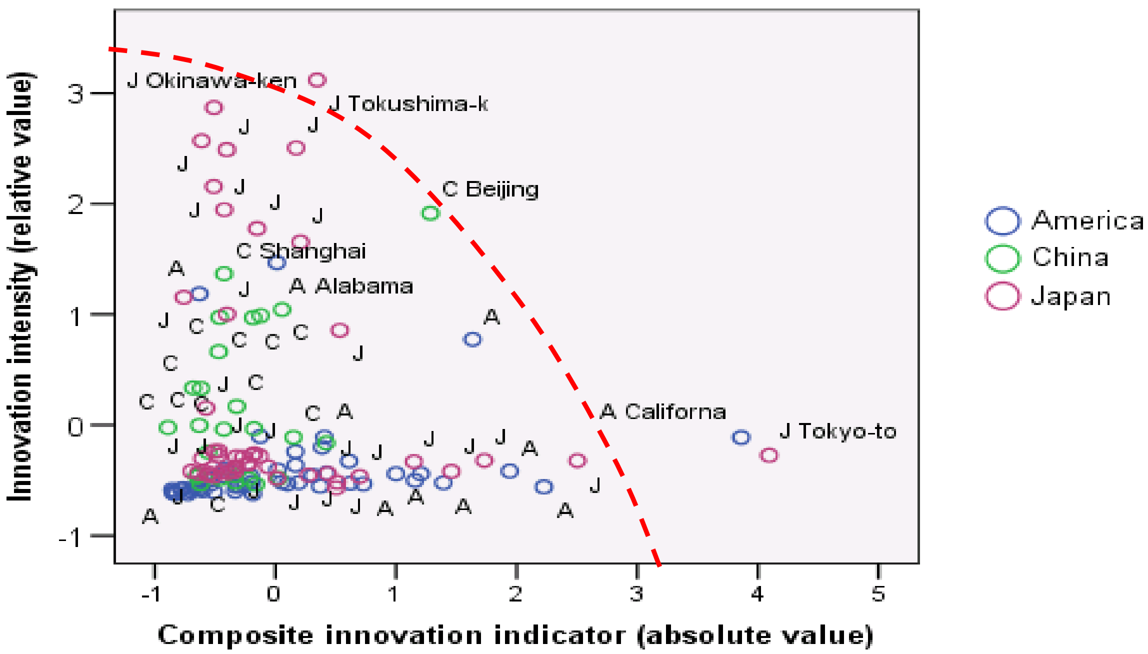


Figure 5: Regional dispersion coefficients for three countries (2003)

Source: edited based on data from China Science & Technology Statistic Year Book, 2006, China bureau of statistics, http://www.jpo.go.jp, http://www.census.gov

It can be seen from Figure 5 that the regions enjoy the highest scores are mostly market driven, and, regions in the US are mostly market driven type, while regions in China are primarily policy driven, and Japanese regions are somehow in between, however also can be clearly classified into two groups of market driven and policy driven.

Conclusion:

The paper concludes on following findings:

1. Innovation performance defined dispersion can be driven by policy as well as market forces, and higher dispersion might be a effective form of innovation resource development in a country if at the same time, economic dispersion over regions can be thus diminished. Therefore, innovation policy at regional and national level should clearly define ownership oriented and innovative region / country oriented functions, leaving appropriate space for active market force operating in local regions, no matter collaborative or competitive. This innovative region based policy framework with ownership innovation policy at national level as a complimentary instrument, can provide better and more effective platform for sustainable development of technology capability in the country concerned.
2. Since there is weak influence on innovation activities cross regions and cross district, regional bounded innovation is rather separate in China, and this may imply that innovation policy in regional level and nation level need to encourage cross region and cross district technology and knowledge transfer, especially cross district innovation networking or cross region innovation clusters.
3. Intra-district and inter-district dispersion on innovation performance (especially

through patent data investigation) in China tends to be high over time and thus nation-wide dispersion becomes wider, therefore, innovation convergence hypothesis in China's case does not hold.

4. Overall increased dispersion level in China, both on innovation and economic performance is primarily contributed by increasingly larger gaps among the three districts. Based on the fact that both intra-district and inter-district dispersion increase over the time duration between 1996 and 2005, not converging to certain level over different geographical regions, it may indicates that such kind of un-evenly distributed pattern in China is an inefficiently and rather fluctuate, which is different from other two typical developed countries, the US and Japan, and regional as well as national innovation policy is therefore highly demanding for effectively developing innovation resources in connection with economic development.

References

Acs Z., Anselin L., Varga.，2002, "Patents and Innovation Counts as Measures of Regional Production of New Knowledge"，Research Policy, Vol.31, pp.1069-1085.

Balconi, M., Breschi, S., Lissoni, F., 2004, "Networks of inventors and the location of academic research: an exploration of Italian patent data", Research Policy, Vol.33, pp.127–145.

Bartlett, C.A., Ghoshal, S., 1990. Managing innovation in the transnational corporation. In: Bartlett, Ch., Doz, Y., Hedlund, G. (Eds.), Managing the Global Firm. Routledge, London, pp. 215–255.

Cowell, F.A., 1995, "Measuring Inequality", Prentice Hall and Harvester Whearsheaf, London

Dowrick,S.,Rogers,M., 2002, "Classical and Technological Convergence: Beyond the Solow-Swan Growth Model", Oxford Economic Papers,54, pp.369-385

Galor, 1996, "Convergence? Inferences from the theoretical models", Economic Journal, Vol.106 (July), pp.1056 -1069.

Griliches, Zvi.,1990, "Patent Statistics as Economic Indicators: A Survey", Journal of Economic Literature, Vol. 28 Issue 4, pp.1661-1707.

Guellec and Van Pottelsberghe., 1999, "Applications, grants and the value of patent", Economics Letters, Vol. 69, Issue 1, pp. 109-114.

Furman, J.L., Porter, M.E., Stern, S., 2002. The determinants of national innovative capacity. Research Policy 31, 899–933.

Keeble D, Wilkinson F., 1999, "Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe", Regional Studies, Vol.33(4), pp. 295-303

Krugman,Paul., 1991, "Increasing Returns and Economic Geography", Journal of Political Economy, Vol.99(33), pp.483-99.

Kuznets, S., 1955, "Economic Growth and Income Inequality", American Economic Review, Vol.45(1),18.

Lundvall, B.A., Johnson, B., Andersen, E.S., Dalum, B., 2002. National systems of production ,innovation and competence building. Research Policy 31, 213–231.

Mansfield, Edwin., 1986, "Patents and Innovation: an Empirical Study", Management Science, Vol. 32 Issue 2, pp173-181.

Mitchell, G.R., 1999. Global technology policies for economic growth. Technological Forecasting and Social Change 60, 205–214.

Romer, P.M., 1986, "Increasing Returns and Long-run Growth", Journal of Political Economy, Vol.94(5), pp.1002-1037.
Solow R.M., 1956, "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economics, Vol.70, pp.65-94.
Willianmson, J.G.,1965, "Regional Inequality and the Process of National Development: A Description of Patterns", Economic Development and Culture Change, Vol. V3, No.4, Part2, pp3-45.
YIFEI SUN., 2000, "Spatial Distribution of Patents in China", Regional Studies, Vol.34.5, pp.441-454.
Varsakelis, N.C., 2001. The impact of patent protection, economy openness and national culture on R&D investment: a cross-country empirical investigation. Research Policy 30, 1059–1068.
Varsakelis, N. C. 2006, Education, political institutions and innovative activity: A cross-country empirical investigation，Research Policy