Innovation Capability: an Analysis of China's Manufacturing Industry

Yanyun Zhao[①], Danbo GUO

(Renmin University of China, Beijing 100872)

Abstract: This paper works out an assessment system of industrial innovation including 50 innovation indicators. Using the census of manufacturing firm data during the 2002-2007 in China, we analyze the industrial innovation capability of China's 31 regions. Besides, we also compare the industrial innovation capability of different regions in independent product innovation firms, process innovation firms, cooperative innovation firms and non-technology innovation firms. All the analyses demonstrate the development level and provide overall information of the industrial innovation capability.

Keywords: Industrial Innovation; Assessment System; Manufacturing Firms

JEL Classification: O18 O31

1. Introduction

In recent years, the topic of innovation has been the focus of attention, especially the system of industrial innovation. Much attention has been focused on the research of technology innovation. A less often discussed issue is the industrial innovation including the technology and non-technology innovation. Freeman (1974) proposed an industrial innovation system including the technology innovation, skill innovation, product innovation, process innovation, management innovation, and organizational innovation. Oslo Manual (OECD, 2005) studied the innovation containing the product innovation, process innovation, market innovation and organizational innovation. Limited studies of China's industrial innovation system focused particularly on the theory. For example, Wang (2006) provided an industrial innovation model involving the policy, technology, environment system, and the assessment framework. However, it lacks the empirical analysis. The objective of this work is to propose an industrial innovation system and to compare the industrial innovation capability of China's 31 regions based on the manufacturing firm data from the census of National Bureau of Statistics, China. In addition, we also consider the diversified innovation behaviors of the firms and compare the industrial innovation capability of different regions in four types of manufacturing firms.

This paper contains the following sections: Introduction (Section 1), the evaluation system of China's manufacturing industry and the methodology (Section 2), the innovation capability of manufacturing industry in China's 31 regions (Section 3), the innovation capability of four innovative types of manufacturing firms (Section 4), and conclusions (Section 5).

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① Professor Zhao Yanyun. Director of Center for Applied Statistics, Renmin University of China, Beijing. Email: cas-kriu@ruc.edu.cn.Danbo Guo. Ph.D. Candidate, Department of Statistics, Renmin University of China, Beijing. Email: tayurun@yahoo.com.cn

2. Evaluation System and Methodology

2.1 Evaluation System

The evaluation system contains 50 innovation indicators which are assigned to seven dimensions (innovation factors). Independent creation (7 indicators) measures the investments in R&D activities, which are considered as key elements required for innovation potential. Innovation realization (7 indicators) measures the innovation output with regard to the output value of new products. Market innovation (7 indicators) measures the effect of market innovation, expressed in terms of exports and sales revenue of products in home. Management innovation (7 indicators) is intended to increase a firm's performance and promotes the firm's sustainable development. It is expressed in terms of the costs and the firm's performance, suggesting that the lower the cost is, the higher the capability of management innovation is. In addition, market exploration ability and the management performance reflect the management innovation indirectly. Skill and equipment innovation (7 indicators) measures the process innovation in terms of the fits assets and personal education. It is helpful to reduce the product cost, improve the labor productivity and the product quality with advance equipment and higher ability staffs. Innovation efficiency (6 indicators) measures the ability of firms to translate innovation inputs into innovation outputs, expressed by the translations of R&D to output value of new products and the output value of new products or exports to firm's profits. Innovation performance (9 indicators) reflects the effect of innovation. It can be expressed by the increase of profits and so on. Table 1 shows the computation of the 50 innovation indicators of China's manufacturing industry.

Table 1: Innovation indicators of China's Manufacturing Industry

Independent Creation
1.1 R&D expenditures **1.2** R&D expenditures (% of sales revenue)
1.3 Increase of R&D expenditures
1.4 R&D expenditures of large firms (% of sales revenue) **1.5** R&D expenditures of medium firms (% of sales revenue) **1.6** R&D expenditures of small firms (% of sales revenue)
1.7 Share of high-tech R&D expenditures(% of manufacturing R&D expenditures)
Innovation realization
2.1 Output value of new products **2.2** Increase of output value of new products
2.3 Output value of new products (% of sales revenue)
2.4 Output value of new products in large firms (% of sales revenue)
2.5 Output value of new products in medium firms (% of sales revenue)
2.6 Output value of new products in small firms (% of sales revenue)
2.7 Share of high-tech new products (% of manufacturing new products)
Market innovation
3.1 Increase of exports **3.2** Increase rate of exports
3.3 Increase of export rate（ratio of exports to industrial sales）
3.4 Increase of sales revenue of products in domestic country ((1-exports /industrial sales)*sales revenue of products) **3.5** Increase rate of sales revenue of products
3.6 Share of high-tech export increase (% of manufacturing export increase)
3.7 Share of high-tech sales revenue of products in domestic country (% of manufacturing sales revenue of products in domestic country)

Management Innovation
4.1 Increase of cost of goods sold per sales* **4.2** Increase of expense of goods sold per sales* **4.3** Increase of Office allowance per sales * **4.4** Increase of finance expense per sales * **4.5** Increase of labor productivity **4.6** Market exploration ability（value of market innovation） **4.7** Management Performance（value of innovation performance）
Skill and Equipment Innovation
5.1 Increase of fix assets of production per person **5.2** Increase rate of fix assets of production per person **5.3** Personal education **5.4** Personal education per sales **5.5** Increase of personal education **5.6** Share of high-tech increase of fix assets of production (% of manufacturing increase of fix assets of production) **5.7** Share of high-tech personal education (% of manufacturing personal education)
Innovation Efficiency
6.1 Ratio of new products to R&D in large firms **6.2** Ratio of new products to R&D in medium firms **6.3** Ratio of new product to R&D in small firms **6.4** Ratio of increase of profit to new product **6.5** Ratio of increase of profit to exports **6.6** Ratio of increase of labor productivity to personal education
Innovation Performance
7.1 Increase of Profit **7.2** Increase of profit rate of assets **7.3** Increase rate of profit **7.4** Increase of rights and interests of owners **7.5** Increase of rights and interests of owners rate (rights and interests of owners/total assets) **7.6** Increase rate of rights and interests of owners **7.7** Increase of laborers remuneration per person **7.8** Increase rate of laborers remuneration per person **7.9** Share of high-tech increase of profit (% of manufacturing increase of profit)

Notes: The inverse indicators are marked by asterisks.

2.2 Data and Methodology

The manufacturing firm data used in this paper come from the census of National Bureau of Statistics, including data from the state-owned manufacturing enterprises and non-state-owned manufacturing enterprises with an annual revenue from principal business over 5 million Yuan. At last, 276790 firms in 2007, 249618 firms in 2006, 165988 firms in 2003 and 155935 firms in 2002 were selected as the sample. Based on the large manufacturing firm data and the evaluation system analyzed in section 2.1, we computed the industrial innovation index, including Summary Industrial Innovation Index (SIII) and Industrial Innovation Index of Innovation Factors (IIIF), which are the instruments used to evaluate and compare the innovation capability of manufacturing industry in China's 31 regions. First of all, the firm data were aggregated from 31 regions in China. Secondly, we indexed the regional data by using the coordinate space from 0 to 100, for facilitating data analysis. The first step is to compute the standardized value (equation (1)). The second step is to compute the indexed data using Standard Normal Distribution Function. In general, a higher value is better. We use equation (2). However, with some criteria the inverse may be true, where the lowest value is the most innovative. The equation (3) is used.

$$z_i = (x_i - \text{average}(x_i))/\text{stdev}(x_i) \quad (1) \qquad y_i = 100 * \phi(z_i) \quad (2) \qquad y_i = 100 - 100 * \phi(z_i) \quad (3)$$

x_i -Data which need to be indexed, z_i- Standardized value, y_i - Indexed Data, Average (x_i) - The average of the sequence, Stdev (z_i)-The stand deviation of the sequence. At last, the index data are used to compute the IIIF and then the SIII. Each criterion has the same weight in the overall consolidation of results. The same weight design is helpful to allow us to “lock” the weight of the sub-factors, which ensure that all the major factors are in equal status (IMD, 2006).

3. Regional comparison- innovation capability of manufacturing industry

3.1. Innovation capability of manufacturing industry: preliminary findings

Table 2 presents the SIII values and the IIIF values of China’s 31 regions. The SIII gives an overview of aggregate innovation capability while the IIIF reflects the innovation capability of 7 innovation factors. As shown in Table 2, regions such as BJ, GD, TJ, ZJ, SH, JS and SC are the innovation leaders, with the SIII values above 60. The innovation leaders are particularly dominant in innovation creation, innovation realization, market innovation, skills and equipment innovation. The group of innovation catching up regions including SD, JL, CQ and other fifteen regions, with the SIII values well below the innovation leaders but above 40. Of these regions, 6 regions lie in the east China, 8 regions lie in the middle China and 4 regions lie in the west China. QH, GZ, XJ, IM, TB, GS make up the group of innovation trialing regions, with SIII values well below 40. They all have weakness in 2 or more innovation factors, such as the innovation creation and innovation realization of IM, the innovation realization, the market innovation and management innovation of TB and GS. Overall, compared to regions in the middle or west China, the innovation capability of regions in east China is higher mainly due to the better innovative environment and innovative infrastructure and the conglomeration of innovation resource such as the place of Jing Jin Ji Area, Yangtze River Delta and Pearl River Delta.

Innovation creation reflects the potential consciousness of firm’s independent innovation in terms of the investment of R&D activities. It is evident that BJ takes the leading slot, with the IIIF values 15 points higher than that of GD who ranks second. SH, CQ and ZJ ranks the third, forth and fifth, respectively. Especially, BJ and CQ are dominant in R&D intensity (R&D/sales revenue), while SH, ZJ and GD perform better in the increase of R&D.

Innovation realization is an innovation factor that has the highest standard deviation, where regions make more difference. There are 8 regions with the IIIF values ranging from 60 to 100. They are TJ, BJ, ZJ, SC, CQ, SH, GD, JL. In particular, BJ, TJ, JL and SC perform better in the intensity of innovation output, while SH, ZJ and GD are dominant in the increase of output value of new products. In addition, TB which lies in the west China is one of the worst performers due to the weakness of all 7 indicators.

For market innovation, regions lie in east China have higher innovative capability than west China due to the resources endowment, the convenient traffic conditions and others. GD, JS, BJ, ZJ, SD, JX, SH and HB are the market innovation leaders, while HL, GZ, SX and XZ are the market innovation trailing regions. The noteworthy exception is that JX with worse innovation creation and innovation realization has better market innovation.

For management innovation, the regions whose SIII values rank in the first ten take up the 70% of the leading lots except the HN, HE and LN. In a word, the regions with higher SIII values and higher management innovation capability are most dominant in market exploration, management performance and labor productivity, while the regions with lower SIII values and higher management innovation capability are most dominant in the low cost of goods sold and office allowance.

On skills and equipment innovation, SC, SH, ZJ and GD take up the leading lots. SC and SH perform relatively better in improving staff skill and the equipment, while the trailing HB performs absolutely worst in the fix assets of production per person and the personal education.

In the first ten innovation efficiency leaders, there are 5 regions lie in east China, 3 and 2 regions lie in the middle and the west China respectively. SD and SC are most dominant in the translation of output value of new product to the increase of profit, TJ in the translation of personal education to labor productivity, and the LN, JL, HL, ZJ, HN in the translation of R&D to output value of new product. On innovation performance, GD, as the leader, has the absolutely advantages in the increase of profit and the rights and interests of owners, and JL, SX in laborers remuneration. However, the notable exceptions are that BJ and SH perform relatively worse on the lower increase rate of profit and the rights and interests of owners.

In a word, regions generally perform at a comparable level in each of these dimensions.

Table 2: Industrial Innovation Index, China, 2007

code	Region	SIII	IC	IR	MAI	MI	SEI	IE	IP
BJ	Beijing	67	85	89	70	75	58	51	41
GD	Guangdong	66	70	70	74	75	61	46	68
TJ	tianjin	65	55	94	55	78	59	71	41
ZJ	Zhejiang	64	62	77	70	70	62	59	51
SH	shanghai	63	69	72	61	76	68	47	48
JS	Jiangsu	62	58	58	72	81	58	43	62
SC	Sichuan	60	45	73	47	65	71	64	57
SD	Shandong	59	52	53	67	81	52	54	54
JL	Jilin	56	47	66	44	68	32	64	69
CQ	Chongqing	55	67	73	47	58	49	49	40
HN	Henan	53	31	37	50	81	45	64	61
HU	Hunan	50	53	44	57	67	34	44	54
LN	liaoning	50	29	49	50	79	33	61	50
FJ	Fujian	50	55	42	47	66	42	38	58
AH	Anhui	48	51	43	53	61	38	45	43
HB	Hubei	46	38	46	60	60	27	50	38
He	hebei	45	36	28	49	71	47	41	46
JX	Jiangxi	45	35	30	63	65	32	44	49
Sa	Shanaxi	45	47	35	29	45	55	42	60
SX	shanxi	45	40	28	48	55	55	40	46
HA	Hainan	44	53	28	54	42	61	37	31
NX	Ningxia	42	26	35	40	40	53	62	39
GX	Guangxi	42	32	46	46	39	34	63	33
Hl	Heilongjiang	42	30	33	30	54	42	54	47
YN	Yunnan	41	38	25	45	63	47	38	28
QH	Qinghai	39	37	22	45	47	17	53	55
GZ	Guizhou	39	40	37	27	42	47	46	36

XJ	Xinjiang	38	25	25	36	34	43	43	60
IM	Neimenggu	37	23	20	49	41	42	37	46
TB	Tibet	35	58	16	29	28	46	23	47
GS	Gansu	34	31	26	38	23	47	45	28

Notes: IC-innovation creation, IR-innovation realization, MAI-market innovation, MI- management innovation; SEI-skills and equipment innovation, IE-innovation efficiency, IP-innovation performance.

3.2 Analysis of innovation capability of manufacturing industry: further findings

3.2.1 Cluster analysis

Based on the index values of the 7 innovation factors, we use cluster analysis to identify regions with similar types of innovation strengths and weaknesses. The regions analyzed can be divided into 3 clusters, namely the strong regions, the catching-up regions and the lagging regions. **The strong regions** include BJ, TJ, SH, JS, ZJ, GD, CQ and SC, which perform the best on almost all innovation dimensions. **The catching-up region**s include HE, LN, JL, AH, FJ, JX, SD, HN, HB and HN, which perform a little better than the strong regions on innovation performance but worse than the lagging regions on the skill and equipment innovation. **The lagging regions** include SX, IM, HL, GX, HN, GZ, YN, TB, SA, GS, QH, NX and XJ, which perform relatively worst in 6 dimensions with the exception of skills and equipment innovation.

Table 3: Average values of different clusters

	IC	IR	AMI	MI	SEI	IE	IP	SIII
Strong	63.74	75.82	61.92	72.29	60.86	53.67	51.19	62.79
Catching-up	42.64	43.95	54.11	69.95	38.07	50.48	52.08	50.18
Lagging	36.72	28.85	39.74	42.65	45.24	44.79	42.67	40.1

3.2.2 Dynamic analysis

Based on the same evaluation system, we compute the SIII values of 31 regions in 2007 and 2003, which are 62 comparative targets all together (Figure 1). Figure1 shows the relationship between SIII values of 2007 (vertical axis) and the SIII values of 2003 (horizontal axis). Regions to the left of the diagonal line have a faster increase of SIII values. From Figure1, we can see that the increase of SIII values in BJ, SH, HN and HU are all above 15 points, followed by SX, ZJ, SD, CQ, SC, YN and NX, above 10 points. Other regions increase slightly. In particular, BJ has a faster increase in independent creation and market innovation, SH in skill and equipment innovation, HN in innovation performance and HU in management innovation. The increases are all greater than 30 points.

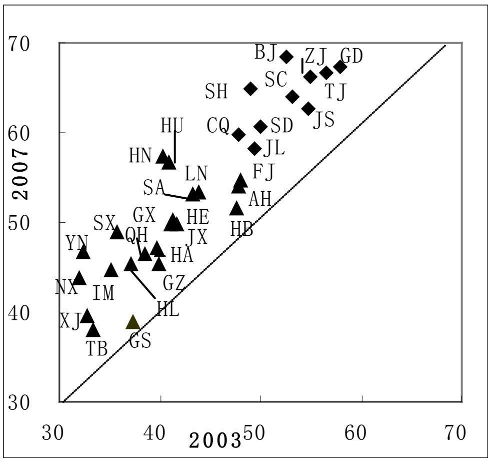

Figure1: Comparison of SIII in 2007 and 2003

As is evident, the innovation leaders have the highest average improvement, with 11.63 points increase. Next are the catching-up regions and the trailing regions, about 10.1 points and 5.97 points, respectively. With respect to the innovation factors, the innovation leaders have a faster average increase in skill and equipment innovation, innovation realization and independent creation, about 26, 19 and 14 points, respectively, while catching-up regions increase significantly in management innovation, skill and equipment innovation and innovation performance, about 24, 16 and 13 points, respectively. However, the trailing regions improve slightly in four innovation factors and decrease significantly in the innovation realization, the market innovation and the innovation efficiency.

4. Regional comparison-innovation capability of four types of manufacturing firms

4.1 The definition of four types of manufacturing firms

In order to analyze the innovation capability of firms with different innovative behaviors, we divided the manufacturing firms into four clusters according to the R&D and output value of new products:

Independent product innovation firm is the firm that has both R&D investments and output value of new products in one year. Our hypothesis is that the output values of new products of the firm all come from the investments of R&D activities on its own. **Process innovation firm** is the firm that has R&D investments but without output value of new products in one year. The assumption is that the R&D investments are mainly aim at improving the production procedure and the production efficiency. The evaluation system only contains 6 innovation factors without the innovation realization. **Cooperative product innovation firm** is the firm that has output value of new products but without R&D investments. The new products of the firms may come from the introduction of new technology or the alliance among enterprises, university and government. The evaluation system includes 6 innovation factors without the innovation realization. **Non-technology innovation firm** is the firm that without R&D and output value of new products. It occupies a space on the market depending on the existing management foundation or other innovation such as management innovation but not the adoption of product innovation or process innovation. However, they also include some technological transition firms that just finish an innovative cycle several years ago and have not entered the new cycle yet. These types of enterprises may depend on the previous product innovation, process innovation or market innovation to support the development of enterprise. The changes of external and internal environment are not enough to promote the enterprise to innovate. The evaluation system contains 5 innovation factors without independent creation and innovation realization.

4.2 Empirical results: preliminary findings

4.2.1 Industrial innovation capability of regions-independent product innovation firms

Product innovation is an important sign of firm’s market success. Generally, firms can improve the capability of product innovation by demand pull and technology push. Figure 2 shows the SIII values of independent product innovation firms in China’s 30 regions (without Tibet). It shows that JL, SH and SX have the largest improvement with an increase above 10 points. In 2007, GD, SH and JL which perform relatively better on four or more innovation factors have higher innovation capability than other regions. Especially in GD, with 5 innovation factors rank in the first fifth regions except the skill and equipment innovation and innovation efficiency. The catching up regions have lower SIII values than the innovation leaders due to the lesser number of advantage innovation factors such as ZJ, TJ, JS, SC and FJ or because of the existence of advantage and disadvantage innovation factors such as BJ, SX and SA. The trailing regions all perform worst in most of innovation factors. For example, HN, HU and TB all have 3 or more factors rank in the last five. In conclusion, a region can be an innovation leader only if it has achieved the overall performance in different innovation factors, the region states excel in one or the other innovation factor may only be catching-up.

4.2.2 Industrial innovation capability of 31 regions-process innovation firms

The process innovation firms are the firms that have R&D activities but not directly develop the new products. On one hand, the investments of R&D may be used for improving the production procedure and the labor productivity; on the other hand, it may be used for developing new products but may not reflect directly in current year, only shown as the accumulation of innovation input which may improve the innovation ability.

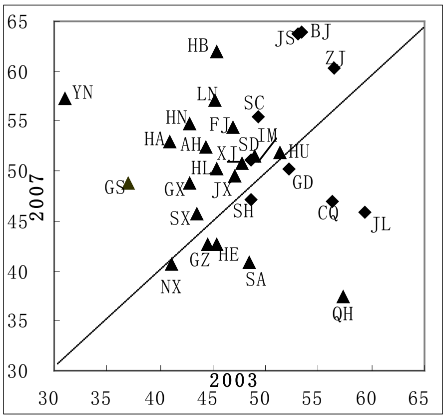

Figure 2: Independent product innovation

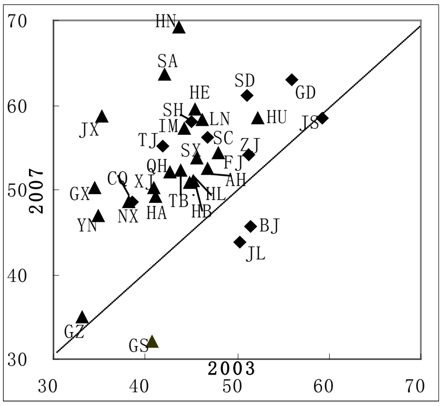

Figure 3: Process innovation

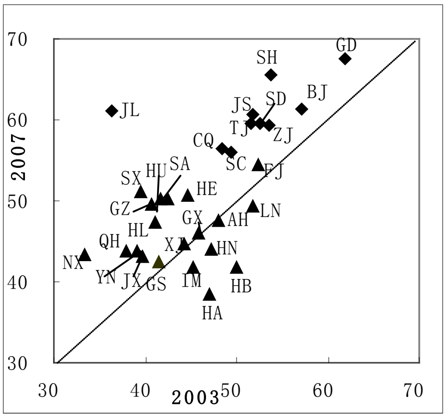

Figure 4: Cooperative product innovation

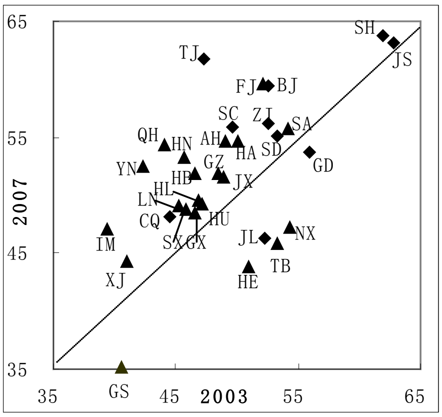

Figure 5: Non-technology innovation

Figure 3 shows the SIII values of process innovation firms in China's 31 regions. It is evident that the SIII values of TJ, QH and YN promote at the largest range. The provinces where the SIII values drop are GS, HE, TB, JL, NX and GD. Compared to other innovation factors, the average level of innovation creation and innovation performance increase rapidly, while the standard deviations of innovation creation and market innovation are greater. The regions that have higher innovation creation and market innovation may have higher innovation capability in process innovation firms such as the innovation leaders SH, JS, BJ. In addition, there are some noteworthy conclusions. The independent product innovation firms in GD and JL show obvious advantages in innovation capability, while the innovation capability of the process innovation firms in these regions is barely satisfactory. On the contrary, in HN and TB where the innovation ability of independent product innovation firms is weaker, the innovation ability of process innovative firms is above the average.

4.2.3 Industrial innovation capability of 30 regions-cooperative product innovation firms

Figure 4 shows SIII values of cooperative product innovation firms in China's 30 regions. The results indicate that YN and HU obtain a significant increase while JL and QH drop at a greatest range. The innovation leaders, BJ and JS, are dominant in innovation realization and market innovation. Of the trailing regions, SA is among the worst performers in market innovation and innovation performance, ranking in the last fifth; SX in market innovation and innovation efficiency, JL in management innovation, skill and equipment innovation and innovation performance. In addition, SH is an example of a region that is a poor performer on cooperative product innovation firms but a good performer on independent product innovation firms and process innovation firms.

4.2.4 Industrial innovation capability of 31regions: non-technology product innovation firms

The comparison of non-technology product innovation firms in 31 regions focus on the market innovation, management innovation and other 3 innovation factors, but not involve the innovation creation and innovation realization. Figure5 shows that SA, JX, HN and GX perform a higher improvement of SIII values, while GS, JL and BJ drop significantly. In 2007, HN, SA, GD and SD make up the group of innovation leaders which perform better in most of innovation factors. The notable exception is the innovation efficiency of GD, ranking 28 in 31 regions. The trailing regions GS and GZ have weakness on four innovation factors due to the unfavorable business environment and worse resource endowment. In a word, the innovation capability of non-technology firms also follows the similar tend "strong in east and weak in west".

4.3 Empirical results: further findings

4.3.1 Correlation analysis

Based on the innovation index of 2007 and 2003, we compute the Pearson coefficients to analyse the effect of innovation factors on the SIII in four types of manufacturing firms (Table4). The result shows that most of the innovation factors are significantly correlated with the SIII in four types of firms except the coefficients of innovation efficiency with SIII in independent product innovation firms (IPIF) and the process innovation firms (PIF). In the independent product innovation firms, the coefficient of innovation realization associated with the SIII is the highest, followed by innovation creation. In the process innovation firms, management innovation and market innovation have higher coefficients, while in cooperative product innovation firms (CPIF) and non-technology innovation firms (NTIF), the management innovation and the innovation performance have the highest coefficients.

Table4: Results of Pearson correlation analysis

Innovative factors	Summary industrial innovation index			
	IPIF	PIF	CPIF	NTIF
IM	0.701**	0.685**	-	-
IR	0.806**	-	0.528*	-
AMI	0.617**	0.752**	0.615**	0.641**

MI	0.85**	0.766**	0.755**	0.886**
SEI	0.638**	0.41**	0.374**	0.442
IE	-0.302	0.242	0.485**	0.346**
IP	0.696**	0.599**	0.608**	0.857**

Note: Coefficients with significance to the level of 1% and 5% are marked with ** and *.

4.3.2 Cluster analysis

The option for clustering is to identify regions with similar patterns of innovation behavior and to find out what types of firms support the innovation capability of different regions. Based on the SIII values of four types of firms in 30 regions in 2007 (without Tibet), we divided the 30 regions into four groups (Table 5): BJ, TJ, SH, JS, ZJ, FJ, SD, GD and SC (cluster 1) are the balanced innovative regions, which has the highest average level of SIII value of independent production innovation firms, the process innovation firms and the cooperative innovation firms, only a little weaker on that of non-technology firms. SX, JL, CQ, GZ and GS (cluster 2) are supported by independent product innovation firms, with the average level of SIII value ranking second in the four groups. However, the average level of SIII values of process innovation firms and non-technology innovation firms rank last. In addition, HE, JX, HN, HU, SA, QH, NX and XJ (cluster3) are supported by the non-technology innovation firms, with the highest average level of SIII value in non-technology innovation firms but the lowest average SIII value of cooperative product innovation firms. IM, LN, HL, AH, HU, GX, HA and YN (cluster 4) are supported by cooperative innovation firms, with the average SIII value only below that of the duster 1.

Table 5: Average index value of different clusters

	IPIF	PIF	CIF	NIF
Cluster1	56.25	53.48	51.74	48.30
Cluster2	**49.39**	42.25	43.58	39.26
Cluster3	44.82	46.64	43.22	**53.60**
Cluster4	41.50	46.04	51.48	46.66

5. Conclusions

Our analysis of innovation capability in China’s manufacturing industries focused on the design of the evaluation system and the comparison of 31 regions with different strengths and weakness of innovation capability and different innovation behavior based on a large data set that includes stated-own and non-state own manufacturing firms (above design size) over the period from 2002 to 2007.

Our results indicate that technology innovation of manufacturing enterprises show obvious scale economic effect due to the resource endowment and the agglomeration economic effect. The comparative advantages of the regions in east China, such as the rich resources, convenient means of transportation and so on, lead to the agglomeration of enterprises, which will be favourable for a firm to enjoy the technology spillover effects from other leading firms. Therefore, the regions in east China have higher technology innovation capability than the regions in west China. In order to investigate the effect of agglomeration on the innovation capability, we computed the Pearson coefficients of SIII with the N and S. N is the ratio of the number of the firms in one region to total number of the manufacturing firms. S is the ratio of the sales revenue of products in one region to total sales revenue of manufacturing firms. It shows that only the coefficients of non-technology innovation firms are not significant. The region with higher number of firms and more sales revenue of products has stronger technology innovation capability. It means that the agglomeration economic effect has significantly positive influence on technology innovation capability.

Table 6: Results of Pearson correlation analysis

	IPIF	PIF	CIF	NIF	SIII
N	0.494**	0.47**	0.225	0.229	0.622**
S	0.715**	0.435**	0.447**	0.299	0.631**

Note: Coefficients with significance to the level of 1% and 5% are marked with ** and *.

Regions can improve the innovation capability by establishing an innovation system with all innovation factors in place. The innovation leaders perform absolutely best in 7 dimensions, especially in innovation creation and innovation realization, with average level of SIII values higher than the second one by 39 and 26 points, respectively. And the catching-up regions, which only state excel in one or the other innovation factors and do not perform well in all of the innovation factors, have weaker innovation capability than the innovation leaders such as the JL, SD. In the future, to keep the innovative advantage and give priority to the inferior factor are the effective measures to improve innovation capability of catching-up regions. The trailing regions are lagging behind its competitors in most of the innovation factors with the exception of skill and equipment innovation. Therefore, these regions can improve their innovation capability by introducing the technology or cooperating with other firms or universities.

The innovation leaders of manufacturing industry with active innovation and diversified innovative behaviour have the highest innovation capability in two or more types of firms. However, the type of firm that supports the innovation capability of a region is different. For example, BJ is supported by cooperative product innovation firms; GD, ZJ, SH and JL by independent product innovation firms; TJ and JS by process innovation firms; SD by non-technology innovation firms. The innovation catching-up region are mainly supported by non-technology innovation firms such as HN, HU, SA and LN. The innovation trailing regions perform worst in almost four types of firms. However, there also exit some noteworthy exceptions. JX, QH and XJ perform relatively better in non-technology innovation firms, YN and IM in cooperative product innovation firms. In general, regions should develop different types of firms according to their characteristics.

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