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A patent based evaluation of technological innovation capability in eight economic regions in PR China

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ABSTRACT

One important indicator of technology innovation capability is the numbers of patents. This paper analyzes the application activities of Chinese patents in the eight economic regions of PR China, covering a time period of 1999–2004. The analysis was classified based on organizations types, subject areas, cooperation and technology distribution. This paper also discusses the relationship between GDP, R&D and the Chinese patent applications in various regions and different organizations.

1. Introduction

Chinese science and technology and the economy have grown rapidly in the last 20 years, which has shown the country to be a huge potential market. The future of Chinese science and technology innovation is promising, said Friedrich Roedler, President of Austria's federal patent office [1]. More studies showed that patent applications are quite a credible indicator for evaluating technology capabilities [2]. Also it is expected that China's patents applications will exceed those from America and Europe in eight years [1]. So it is very important to study Chinese patents held by Chinese individuals or organizations. In recent years, Sun [3,4] and Fai [5] had analyzed the relationship between the technological capabilities or industrial innovation and Chinese intellectual property data by different ways. According to Sun's study, Chinese patents have been highly clustered in two groups of provinces: one is the economically fast growing coastal provinces; and the other is inland provinces with large bases of populations [3], while some indicators such as patent grants, new product sales and R&D were used to examine the spatial patterns of industrial innovation in the two groups of provinces in China during the 1990s [4]. Fai studied the pattern of domestic patents from 1994 to 2002 and listed the Top 10 provinces (geographic regions) arranged by the patent applications and patents granted [5].

The purpose of this paper is to further analyze the patent data and evaluate the technology innovation abilities in China based on eight economic regions. The data, published by National Bureau of Statistics of China [6], have shown that the GDP and R&D expenditures were extremely imbalanced in China's eight economic regions during the period 1999–2004. North Coast owned the highest R&D expenditures, which was nearly 20 times more than that of North West, and the GDP's ratio of North Coast–North West was about six. Therefore, the Sci&Tech development and economic growth was much more different in the different economic regions in China. So it is necessary to study the patent distribution of the eight economic regions. In order to map the relations between the different growth levels and the technology innovation capability in the eight economic regions, the patent indicators in the eight economic regions were compared.

The eight economic regions, named by the Development Research Center of State Council PR China, include the North East (Heilongjiang, Liaoning and Jilin), the North Coast (Beijing, Tianjin, Hebei and Shandong), the East Coast (Shanghai, Jiangsu and Zhejiang), the South Coast (Guangdong, Hainan and Fujian), the Middle Changjiang River (Anhui, Hubei, Hunan and Jiangxi), the Middle Yellow River (Henan, Shanxi, Neimenggu and Shaanxi), the South West (Sichuan, Guizhou, Yunnan, Chongqing and Guangxi) and the North West (Gansu, Ningxia, Qinghai, Xizang and Xinjiang) [7]. Hongkong, Macao and Taiwan were not analyzed in this paper.

2. Date source and method

We used Chinese patents abstract database (CD-ROM) to collect all Chinese invention patent filings by Chinese residents and foreign invested multinational enterprises that have registered in China by the application year. Since the publication date of a patent publication is generally 18 months later than the application date, in order to make exact original data, we had just downloaded

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the data until 2004 filing year and analyzed the data covering 1999–2004 filing years, which was used to describe the general character, and then classed them based on the eight economic regions of China. In this paper, we combined the technology innovation indicators with informetrics to analyze the patent application numbers, patent intensity indicators, technical fields, main IPC and the applicants.

3. Patent patterns in PR China

China enacted its first patent law in 1984, which came into force on April 1, 1985. The yearly patent application numbers have increased steadily [7]. The aims of the patent law are to promote innovative activities, and to facilitate the movement of technology from governmental research and development laboratories to industries [8]. While the promotion of science and technology and the sustained and rapid economic growth in China have shown China to be a huge potential market, therefore, this has stimulated a recent sharp increase in patent applications both from home and abroad [9]. Chinese technological activity grew rapidly in recent years, so did the number of patent applications from the whole country. The annual growth rate of patent applications was 48.7% and the quantity of that were 221,388 during the period 1999–2004 (Table 1).

3.1. Technical field

The distributing pattern of patents' technical fields reflects the national technological innovation, so the number of patents is an important indicator of science and technology for evaluate the National Innovation System (NIS). According to the eighth edition of The International Patent Classification (IPC), the whole area of technology is divided into a range of sections, classes, subclasses and groups which almost includes 60,000 subgroups.

In this section, we look at evidence for the technological field development paths pursued by China. We selected the top ten technical fields based on the number of patents in Table 1. From 1999 to 2004, China had accumulated most of its technology in the class A61 (human necessities-medical or veterinary science; hygiene) (12.3%), which constitutes the most important area of Chinese technological accumulation (Table 2). It seems likely that China has paid more attention to advancing technology capabilities of medicine and hygiene from 1999 to 2004.

Looking into the subclasses, China accumulated technology mostly in the Chinese traditional medicine, soft drink, food, Chinese input method (a language input software used in computer to typewrite Chinese), etc, while the foreigners' patents in China focused mostly in some high tech fields, such as optical recording methods, wireless data transmission, electric communication technique, TV system, transmission equipment, semiconductor and TV accessories. There was an obvious shortage in high tech fields of China compared to the patent filed outside China, especially to Japan, USA, Korea and Germany, which hold the majority of the patents in information technology [10,11].

3.2. The applicants

There were three major applicant groups in China, i.e., enterprises, universities and research institutes, the application numbers of which were 63,244, 25,695 and 16,563 during the period of 1999–2004. The number of applications from universities and research institutions were relatively low. And this phenomenon emerged along with the Chinese Patent Office started accepting patent applications in 1985 [5]. Although the enterprises had a higher level of applications, only 0.17% Chinese owned enterprises had its own invention patents according to the statistic by Chinese Patent Office. It directly resulted in the higher payout on licence to mobiles, computers, CNC lathes, etc, which occupied the 20%, 30%, 20–40% of its selling incomes [12]. While there were six enterprises in the Top 10 enterprises from foreign invested multinational enterprises (LG Tianjin Co. Ltd., FOXCONN, Inventec Corporation, Shanghai LG Electronics Co. Ltd., Macronix International Co. Ltd. And LG Electron (China) Research Center), in which three were funded by LG (Table 3). When it comes to research institutions, all of the Top 10 research institutions were from the Chinese Academy of Sciences (CAS). The reason why institutions of CAS monopolized the Top 10 research institutions is that CAS is the biggest, the most important and the most excellent organization in China [13].

An analysis of patent applications on China Universities by Zhejiang University of Technology has shown that 75% colleges had no or very little patent applications [14]. So the bad status of colleges in Chinese innovation activities has persisted for a long time and will continue in the future if the idea of recognizing research papers, but ignoring patents does not change.

The Top 10 applicants of different groups arranged by the number of its patents in the six years had been listed in Table 3.

Table 1
Patent applications: 1999–2004

	1999	2000	2001	2002	2003	2004	Average annual growth rate	1999–2004
The total number of patent applications	12,942	20,546	23,297	32,632	44,987	86,984	48.7%	221,388

Table 2
Top 10 main IPC (3 digits) of China, 1999–2004

Rank	Technical field\maim IPC (3 digits)	Number of patents	(%)
1	A61 (Human necessities–medical or veterinary science; hygiene)	27,324	12.3
2	H04 (Electricity–electric communication technique)	16,782	7.6
3	G06 (Physics–computing; calculating; counting)	12,739	5.8
4	C07 (Chemistry; metallurgy–organic chemistry)	11,155	5.0
5	H01 (Electricity–basic electric elements)	9724	4.4
6	A23 (Human necessities–foods or foodstuffs; Their treatment not covered by other classes)	8818	4.0
7	G01 (Physics–measuring; testing)	8280	3.7
8	C12 (Chemistry; metallurgy–biochemistry; beer; spirits; wine; Vinegar; microbiology; enzymology; mutation or genetic engineering)	8122	3.7
9	A01 (Human necessities–agriculture; forestry; animal husbandry; hunting; trapping; fishing)	6210	2.8
10	C08 (Chemistry; metallurgy–organic macromolecular compounds; Their preparation or chemical working-up compositions based thereon)	5489	2.5

4. Analysis of the patent filing in eight economic regions in PR China

The objectives of this section were to collect statistical data on eight regions' patent applications in China, to explore the distribution of different regions at the level of numbers, applicants, patent intensity indicators and technical fields, and to provide a better understanding of the patent activities in this developing country and give relative analysis on technology innovation capability of the eight economic regions.

4.1. Number of patents in eight economic regions in PR China

Data revealed that the numbers of patent applications from the China eight economic regions were increasing rapidly (Table 4). The East Coast Region, whose total number of patent applications ranked the second in all the eight regions, held the highest annual (2003–2004) increase rate of 67.5%. It is expected that the East Coast Region's patent applications will exceed those from the North Coast Region in coming years, whose total number of patent applications ranked first now but the annual increase rate ranked only third.

Patent percentage contributed from the eight regions to the total number of Chinese patent applications is shown in Fig. 1. A total of 29% of patents applications were filed in North Coast and 25% in East Coast. Together these two regions contributed more than 50% of patents applications filed in China.

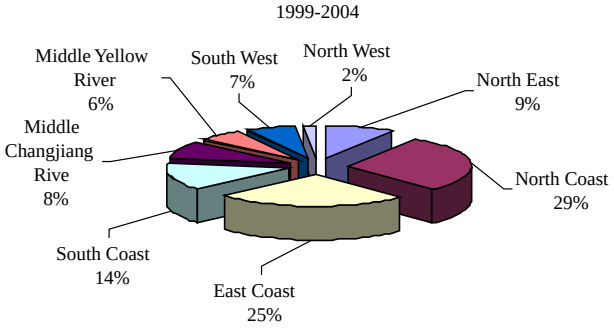

Fig. 1. Percentage share of the eight economic regions contributing to the total number of Chinese patent applications in PR China (1999–2004).

4.2. Analysis of the patent activities of enterprises, universities and research institutes

The underlying principle, rarely formulated precisely but ever present is that originality can be organized, and if provided more people can be equipped with technical knowledge and are brought together in larger groups, more new ideas can be generated; and mass production will produce originality just as it can produce sausages [15].

The preceding analysis showed that the patent numbers of enterprise–university–research institutes occupy the absolute dominating status with the proportion of 57.3% of the total number of the patents applications. When it comes to the eight economic regions, compared with the other five regions the East Coast, North Coast and South Coast had much more patents applications, especially for the East Coast and North Coast regions, whose advantage were remarkable (Fig. 2).

The high patent filing is most likely due to the fact that there are much more colleges, enterprises and research institutions which had better technological innovation capabilities in North Coast region (including Peking, Hebei, Shandong and Tianjin) and East Coast Region (including Shanghai, Jiangsu and Zhejiang). For example, most of top 50 colleges such as Tsinghua University and Tianjin University were in North Coast region, and Shanghai Jiaotong University, Zhejiang University and Fudan University were in East Coast region. There are 12 of the Top 20 research institutions arranged by patent application numbers belong to East Coast Region

Table 3
Top 10 organizations of different groups: 1999–2004

Top 10	Enterprises	Number	Research institutions	Number	Universities	Number
Top 1	LG Tianjin Co., Ltd.	5233	Dalian Institute of Chemical Physics, CAS	708	Tsinghua University	2513
Top 2	Huawei Technologies Co., Ltd.	5181	Shanghai Institute of Optics and Fine Mechanics, CAS	616	Shanghai Jiao Tong University	2208
Top 3	Union Gene Technologies Co., Ltd	3571	Institute of Chemistry, CAS	485	Fudan University	1123
Top 4	Sinopec	2080	Institute of Metal Research, CAS	462	Zhe Jiang University	1009
Top 5	FOXCONN	1512	Changchun Institute of Applied Chemistry, CAS	413	South China University of Technology	557
Top 6	ZTE Corporation	928	Institute of Coal Chemistry, CAS	365	Wuhan University	552
Top 7	Inventec Co.	813	Research Center for Eco-Environmental Sciences, CAS	337	Tianjin University	489
Top 8	Shanghai LG Electronics Co., Ltd.	800	Institute of Computing Technology, CAS	280	Nanjing University	488
Top 9	Macronix International Co., Ltd.	627	Changchun Institute of Optics Fine Mechanics and Physics, CAS	276	Harbin Institute of Technology	470
Top 10	LG Electron (China) Research Center	535	Institute of Semiconductors, CAS	270	East China University of Science and Technology	467

Table 4
The number of patent applications from the eight economic regions: from 1999 to 2004

S. No.	Economic regions	1999	2000	2001	2002	2003	2004	Annual increase rate (%)	1999–2004
1	North Coast	3337	4976	7059	10,109	13,003	25,271	51.4	63,755
2	East Coast	2502	6117	5344	7380	10,654	23,786	67.5	55,783
3	South Coast	1372	2045	2709	4384	6696	14,547	62.7	31,753
4	North East	1630	2223	2464	3111	4277	6779	33.9	20,484
5	Middle Changjiang River	1348	1830	2086	2706	4025	6141	36.2	18,136
6	South West	1227	1501	1733	2439	3122	5254	35.0	15,276
7	Middle Yellow River	1204	1389	1447	2014	2552	4156	29.7	12,762
8	North West	322	465	455	489	658	1050	28.8	3439

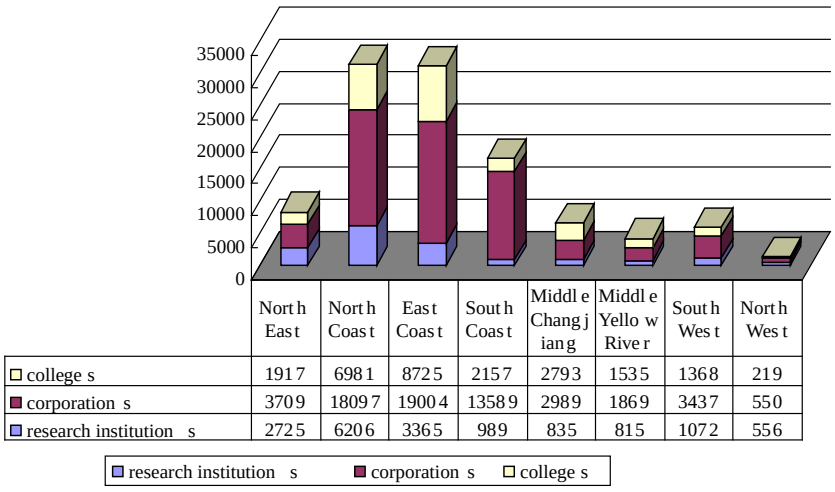

Fig. 2. The organizations' patents by three groups: 1999–2004.

and North Coast region. And all of the Top 20 corporations locate in East Coast Region, North Coast region and South Coast Region. It suggests that the distributing of innovation entities is unbalanced among the China eight economic regions. Much more colleges and research institutions assemble at East Coast and North Coast, especially at Beijing and Shanghai. A major part of corporations locate in East Coast, North Coast and South Coast, particularly in Tianjin, Beijing, Shanghai and Guangdong. Therefore, the government ought to highlight the irrationality and give some underlying policies and measures to the regions that have comparatively less innovation entities to stimulate the organizations' technology innovation capability, such as South West, North West, Middle Changjiang River, Middle Yellow River and North East.

Through the analysis of the different types of organizations in every region we find that the enterprises own more patent applications in every region, except in North West where patent applications filed by research institutions were premier. Whereas, there are more than 35% patents applications from Foreign invested multinational enterprises in the Chinese Hi-tech enterprises applications. It means that the Chinese Hi-tech enterprises regale on much more preferential policies, but the property rights of their patents are not remained with China [16]. If we neglected the two regions of North East and North West, we conclude that in the other six regions the numbers of colleges' patents applications were more than research institutions'.

4.3. Indicators of Patent Intensity

WIPO introduced three patent intensity indicators in its patent report (2006 and 2007 edition) that compare patent filings with other indicators, namely population, gross domestic product (GDP) and research and development (R&D) expenditures [17]. We used these three indicators for reference in our studies to achieve more cross-region comparisons by weighting the number of patents applications by measure the regional size and economic activities.

4.3.1. The number of patent applications per million population

Fig. 3 shows the number of resident patent applications per million inhabitants. East Coast and the North Coast had the highest rate of patent applications per million populations at 67.5 and 58.0. Next in turn were South Coast and North East at 42.7 and 31.9. The other four regions had the lower rate at about 10 each of which were less than 1–5 that in East Coast.

4.3.2. The number of patent applications per R&D expenditures

Fig. 4 shows the number of patent applications per 100 million yuan of research and development (R&D) expenditures from 1999 to 2004 measured in RMB. Based on the data published by The National Bureau of Statistics of China we concluded that Chinese R&D

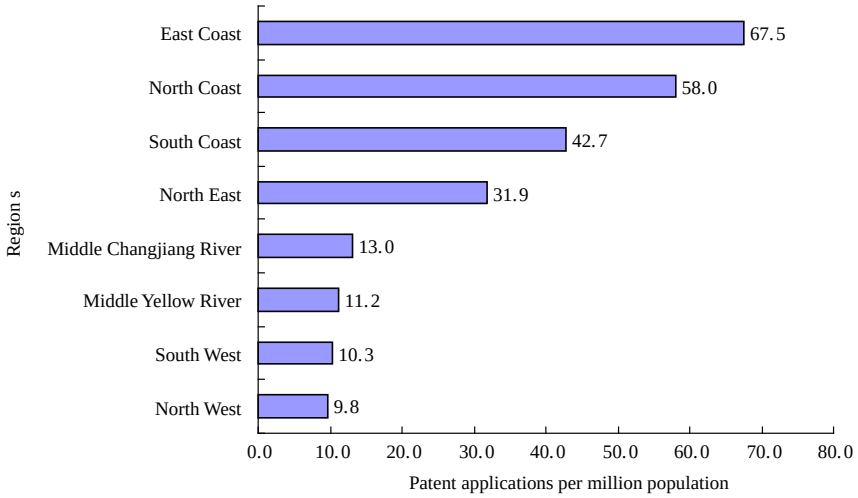

Fig. 3. Patent intensity indicators: the number of patent applications per million population note: population – the total resident population of each region.

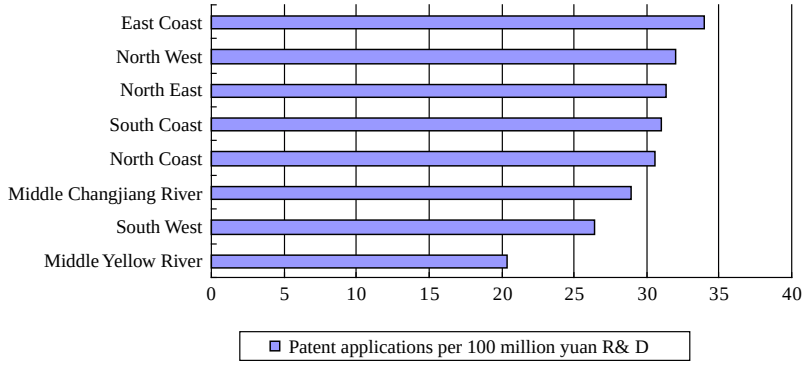

Fig. 4. Patent intensity indicators: the number of patent applications per 100 million R&D note: research and development – total gross spending on research and development (not separated into government or business spending).

expenditures grew rapidly in the six years with a high annual growth rate of 25% [6].

The differences in patent applications among the eight regions were small when weighted by research and development expenditures. None but Middle Yellow River had a lower rate of patent applications per R&D expenditures. The highest rate still remains in East Coast. Especially in North Coast and East Coast, although the two regions had the most (R&D) expenditures its indicators still remained the normal or much higher level (Fig. 4). This should attribute to the large numbers of patents applications from the two regions (Table 4).

This result demonstrated that the more R&D expenditures, the more innovation activities and output of patents applications. Our conclusion is also consistent with the previous findings that there were obvious relativity between patent output and research and development (R&D) expenditures [18].

4.3.3. The number of patent applications per gross domestic product

The number of patent applications filed worldwide had increased from 884,400 in 1985 to 1,599,000 in 2004. The average annual rate of increase in total patent filings since 1995 was 4.75%. The growth rate was comparable to the overall increase in economic activity over the same period, the average annual growth in world GDP had been approximately 5.6% [19].

However, the average annual rate of increase in total patent applications from 1999 to 2004 was 48.7% in China. And the average annual growth in GDP in China was 13.3% (calculated from the original data, not corrected) during the same period. The growth rate was much higher than the overall increase in economic activity over the same period.

Fig. 5 shows the number of patent applications per 100 billion yuan of GDP, where GDP from 1999 to 2004 measured in RMB.

The North Coast had the highest rate of patent applications per GDP, which had 0.38 patent applications when it created 100 billion yuan GDP. Next in turn were East Coast, North East and South Coast at 0.29, 0.26 and 0.22. The other four regions had the lower rate, each of which was less than a half of that in North Coast.

The precise analysis of the three patent intensity indicators shows the imbalance of technology innovation capability among the eight economic regions. The three indicators reflect that North Coast, East Coast, South Coast and North East have higher innovation capability when weighted by population and GDP. But when it comes to R&D, the difference of patent applications weighted by R&D in the eight regions was little besides South West and Middle Yellow River. These results indicate generally that only with more R&D expenditures, can the output of patent applications be increased. But the R&D expenditures of North East, Middle Changjiang River, Middle Yellow River, South West and North West were much less than that of the other three regions. As a result, the

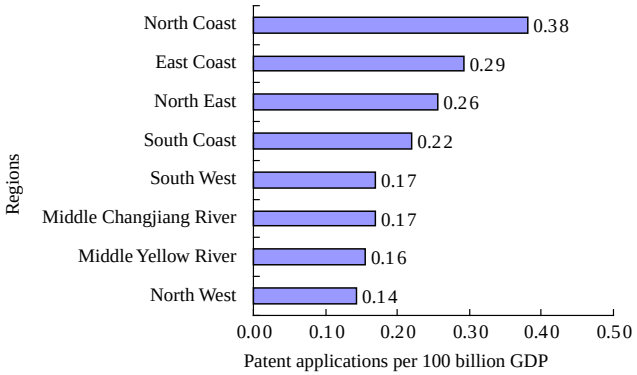

Fig. 5. Patent intensity indicators: the number of patent applications per 100 million GDP note: GDP – the gross domestic product of each region.

number of the former five regions' patent applications was lower too. The number of patent applications per Million Population of South West, Middle Changjiang River and Middle Yellow River was little for their Top 3 highest populations among the eight regions. The indicator of GDP (Fig. 5) indicates that North Coast, East Coast, North East and South Coast have larger number of patent applications with equal GDP production. It seems likely that the patents contribute to the GDP more or less higher in the region with higher technology innovation capability.

4.4. Comparison of the technical field

Preponderant technical field is one of the important indicators of technology innovation capability. Enhancing and developing preponderant technical field becomes an important task in regions' choice of strategy for science and technology.

By analyzing the eight regions technical fields (Table 5) we could see that there was a serious lack of balance of technical development among the eight regions in China. Most preponderant technical fields distributed in North Coast and East Coast and some in South Coast such as H04 (electricity–electric communication technique) and F24 (mechanical engineering; lighting; heating; weapons; blasting–heating; ranges; ventilating). The reason is that North Coast had gathered many companies which were focusing on electric communication technique, such as Lenovo, Datang, ZTE Corporation, China Mobile, Founder, etc. On the other hand, some famous companies in the fields of heating; ranges; ventilating, such as Haier, Hisense, Beijing Sunda Solar Energy Technology, are located in North Coast of China.

It suggests that the technical fields of a region were decided by those major innovation entities who contribute most of the re-

Table 5
Top 20 technical field in each regions: 1999–2004

S. No.	North East		North Coast		East Coast		South Coast		Middle Changjiang River		Middle Yellow River		South West		North West	
	IPC	Number	IPC	Number	IPC	Number	IPC	Number	IPC	Number	IPC	Number	IPC	Number	IPC	Number
1	A61	3327	A61	7761	C07	5563	H04	7078	A61	2999	A61	2477	A61	2936	A61	574
2	A23	1398	H04	3767	A61	4363	A61	2424	A23	946	A23	712	A23	977	A23	337
3	G01	805	G06	2828	C12	3195	G06	2219	E04	918	A01	451	A01	660	C07	177
4	C07	762	C07	2559	H04	2677	H01	982	G01	726	G01	451	C07	592	A01	171
5	A01	716	F24	2269	H01	2433	A23	859	A01	678	G06	409	C12	555	C12	123
6	C09	633	G01	2268	G01	2150	G01	776	C12	592	C12	332	G06	462	C01	104
7	C12	629	A23	2148	G06	1843	A01	615	G06	588	H01	317	G01	455	C09	102
8	C08	521	C12	1964	C08	1417	C12	613	C07	527	C07	303	H04	375	C08	87
9	B01	500	C08	1802	A23	1372	G02	612	H04	452	C10	300	C08	341	G01	84
10	H01	442	H01	1734	A01	1230	C09	601	C09	408	B01	295	C09	312	B01	73
11	H04	371	B01	1663	C09	1039	C08	571	C08	404	H04	272	C01	275	C10	71
12	G06	364	A01	1624	B01	991	C07	567	H01	354	C09	254	H01	246	H01	71
13	C04	335	C10	1577	F16	812	H02	439	C04	313	C01	243	B01	238	G06	61
14	C22	327	C09	1196	H02	795	F24	324	H02	303	C04	223	F16	231	C22	56
15	C10	314	D06	1129	C02	689	B65	317	B01	289	H02	187	C22	228	C05	52
16	C02	305	F25	890	G11	626	B60	316	C22	271	C22	169	C04	224	C04	46
17	C01	289	F04	880	G02	622	A47	301	B60	268	F16	167	B60	190	B60	39
18	F16	277	H02	865	C01	578	B01	289	C01	266	C08	160	C02	176	H02	39
19	H02	255	C01	860	F24	568	C02	269	F16	228	B60	154	E04	173	F16	36
20	E04	237	C02	838	C04	539	H05	262	F24	226	F24	154	F24	164	F24	34

gion's patent applications. In order to reduce the difference of the preponderant technical field, government ought to make some efficient policies and measures to support the existing entities to improve their patent output in the less preponderant fields and to attract some Hi-tech enterprises with their own intellectual properties.

5. Conclusions

Study results indicate that the number of Chinese patent applications increased rapidly during the six years 1999–2004. Some technical fields had been paid much more attention, especially in the fields of medical or veterinary science. The technical innovation capability also clearly increased in these fields.

This study reveals that the number of patent applications from universities was still low, because of recognizing research papers, but ignoring patents in campus. And this phenomenon has existed for a long time since the patent law came into force in 1985. The enterprises had the most patent applications, whereas only 0.17% of all the Chinese enterprises had invention patents. So increasing the R&D expenditures to enterprises and strengthen the power of innovation became much more important to Chinese sustaining development in science and technology, economy and society. There is a wide gap for the organizations to strive to bridge.

The analysis of the patent applications of the eight regions showed that number of patent applications was unbalanced in the China eight economic regions during the period 1999–2004. More than 50% of the Chinese patent applications were filed from the North Coast and East Coast. And the annual growth rates of the two regions were also higher than other regions except South Coast. It means that the advantage of the two regions will prevail continually and maybe exist for a long time. For the little difference of R&D indicator among the eight regions compared to the big difference of patent applications we conclude that the more R&D total gross spending on research and development, the more patent applications. So in order to reduce the difference in different regions there should be much more R&D expenditures in the regions with low patent input.

The North Coast and East Coast contributed most of the Chinese patent applications. There are some interesting phenomena when we compare the numbers and indicators of the two regions. The North Coast is the premier region in terms of aggregate number of patents (see Table 4), and the sum of the institutional patents are 30,094 for the East Coast, and 30,288 for the North Coast (see Fig. 2), so more or less equal, yet in view of the values of patent applications per million population (see Fig. 3) and that of patent applications per 100 million yuan R&D (see Fig. 4), the East Coast out performs the North Coast. It means that the number of each person's patent applications in the East Coast is on average higher than that in the North Coast, and it also indicates that the East Coast is more efficient in technology innovation than the North Coast. Therefore, domestic entities and/or foreign investing entities in the North Coast including colleges, corporations and research institutions, should pay more attentions to the location of future S&T efforts to keep up with the advance step of the East Coast.

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