A Tale of Two Cities: A Comparison of Patent-based Innovative Performance of Domestic and Multinational Companies in China

Dr. Zheng Liang[1] and Dr. Lan Xue[2]

China Institute for S&T Policy (CISTP)

School of Public Policy and Management (SPPM)

Tsinghua University, Beijing 100084

People's Republic of China

Draft Paper for Joint Symposium of U.S.-China Advanced Technology Trade and Industrial Development, October 23-24, Beijing, China

[1] Associate Professor, School of Public Policy and Management(SPPM), Tsinghua University; Assistant Director, China Institute for Science &Technology Policy at Tsinghua University (CISTP). Email:liangzheng@tsinghua.edu.cn

[2] Professor and Dean, School of Public Policy and Management (SPPM), Tsinghua University; Director, China Institute for Science &Technology Policy at Tsinghua University (CISTP). Email:xuelan@tsinghua.edu.cn

Introduction

The year of 2008 marks the 30th anniversary of China's openness and economic reform, which has generated astonishing high economic growth in China for the past 30 years. According to the World Bank's statistics (World Bank, 2003), for example, the average growth rate of Chinese Gross Domestic Product (GDP) during the 1980s and the 1990s were 10.1% and 11.2%, respectively, making it one of the fastest growing economies in the world. The abandonment of centralized planning and the establishment of market institutions, as well as the market opening to foreign investment, were credited as keys to the success of this growth. However, the economy miracle of China is often described as the result of intensive inputs such as labor, resources and capitals, not oriented on innovations. Is it true? How about the innovative performance of China's domestic enterprises, in comparison with their competitor from abroad? In this paper, we will explore it mainly based on patent data, the most popular indicator used to estimate the innovative performance of firms.

The conventional wisdom about IPR is that strong IPR protection generates incentives for the investment in Research and Development (R&D) and hence for the technological progress in society (Arrow, 1962; Nordhaus, 1962; Scherer, 1972). In addition, IPR protection also helps to disseminate technical information and reduce social cost (Malchup, 1958), which is always referred to as "information disclosure effect". All of these not only make patent become the indicator of innovative performance and capabilities, but also change it into the source of new innovations. At the same time, protecting IPR through assigning monopolistic right to the knowledge also entail economic costs. The monopoly position on the technology deters other firms from trying themselves to invent "in the neighborhood" (Scotchmer and Green 1990; Green and Scotchmer, 1995). As the result, interactions between patent players have multidimensional effect on innovation.

But understanding patent's role in China is further complicated by the fact that Chinese economy in the reform era has been far more open than many other countries at its comparable stage. The patent system in China from the very start faced with the double challenges of meeting the demand of multinational companies which required strong protection of IPRs while at the same time satisfying the appeal of domestic companies which favored an IPR regime conducive to technology transfer and diffusion, which may lead to the strategic utilization of this system and make which patenting behaviors couldn't reflect the real innovative performance to some extent (Liang and Xue, 2010, forthcoming).

Despite these obstacles, in this paper, using some empirical evidence from China, we still try to analyze the patenting behaviors of domestic and multinational firms in China and compare their innovative performance based on patent data. Our analysis will be carried out at the two levels. The first level is based on data at the national

level, including patent data on application, grants, and so on. The second level is based on data at the enterprise level. Here we use 500 China's biggest corporations in 2006[3] as the sample. From the list provided by SIPO[4], we selected 652 related corporations[5] which have at least 1 invention[6] application until the end of 2004 and found 16109 pieces of invention application of these firms during April 1st, 1985 to Dec 31st, 2004, which account for 4.62% of the total domestic invention applications in same period. For each piece of invention application, we obtained the following information of it: application date, grant date, prior-right[7], patentee, inventors and their residences, IPC section number, and IPC class number[8]. As the comparison samples, we choose Fortune Global 500 list (2006) as the population of investigation. From the list provided by SIPO of foreign firms that have at least 1 invention application until the end of 2004, we selected 775 related corporations. We then searched in SIPO's database and found 108747 pieces of invention application by these firms during April 1st, 1985 to Dec 31st, 2004, which account for 30.47% of the total foreign invention applications in China the same period.

The remainder of the paper is organized as follows: part Ⅰ is a brief introduction of the evolution of China's patent system; part Ⅱ investigates the patenting behavior of multinational firms and domestic players based on national level data; part Ⅲ and part IV evaluate the innovative performance of domestic and multinational firms in China based on the firm level dataset described above. Part V concludes the paper.

Ⅰ. Background: The Evolution of China's Patent System

China enacted its first patent law in 1984 which came into force in April, 1985. In general, the Chinese patent system shares more similarities with the Japan patent system than with that of the United States. For example, the primary purpose for China's patent law is to facilitate diffusion of new technologies, which is demonstrated by the kinds of patents allowed (invention, design, and utility model),

[3] The list are jointly issued by Chinese Enterprise Alliance and Chinese Entrepreneur Association annually since 2004 and ranked by total revenues. The 2006 ranking list could be acquired from http://www.cec-ceda.org.cn/huodong/2006china500.(in Chinese)

[4] SIPO is the abbreviation of State Intellectual Property Office of the People's Republic of China.

[5] One same firm might has several sub firms applying for patents in China.

[6] Here we use invention data instead of patent data because inventions represent most technology creation comparing with other two forms of patents. And this is also the only comparable patent field between multinationals and domestic firms because most of the patent applications of multinationals in China are In-service inventions, and domestic firm is also the only dominant applicants in domestic In-service invention applications.

[7] In patent, a priority right or right of priority is a time-limited right, triggered by the first filing of an application for a patent. The priority right belongs to the applicant or his successor in title and allows him to file a subsequent application for the same invention and benefit, for this subsequent application, from the date of filing of the first application for the examination of certain requirements. When filing the subsequent application, the applicant must "claim the priority" of the first application in order to make use of the right of priority. The period of priority is usually 12 months for patents.

[8] The Strasbourg Agreement (of 1971) concerning the International Patent Classification provides for a common classification for patents for invention including published patent applications, utility models and utility certificates. The International Patent Classification (IPC) is a hierarchical system in which the whole area of technology is divided into a range of sections, classes, subclasses and groups. This system is indispensable for the retrieval of patent documents in the search for establishing the novelty of an invention or determining the state of the art in a particular area of technology.

their shorter grace period, the adoption of the principle of ‘‘first-to-file’’ instead of “first-to-invent’’, public disclosure of the invention after 18 months, and mixed requirement of single and multiple-claims. Typically, the adoption of ‘Petit Patents’ such as utility models and designs are mainly based on the intention to encourage gradual innovation which is often very important for the native applicants. This ambition had been achieved partially according to some empirical studies (Liu et. al, 2003; A. Hu, 2006)

Generally, China’s patent system has evolved through three stages. The first stage is from 1985 to 1992, which is the founding stage of China’s IPR system. Before 1985, China only had a Management System of Science & Technology Outcome, which presumably belonged to the entire country. While China’s first patent law made it possible for individuals to file patents, it was difficult for inventors to extract monopoly rents except to get some promised material rewards (Alford, 1995). At the same time, without the permission of relevant administrative department in the government, SOEs couldn’t deal with their patents autonomously, for example, licensing out. These limitations dampened the enthusiasm of SOEs as well as their technical staffs who were key players in industrial R&D. The first Patent Law also excluded chemical, pharmaceutical, and alimentary or process inventions from patent coverage, which were regarded as the intended predilection on domestic industries and additional disadvantages for foreign applicants. These issues reflected the dynamic balances between stimulating indigenous innovations and sharing the worldwide knowledge pools by enforcement of patent protection.

The second stage is from 1992 to 2000, when China’s patent system made substantial progress. In the first revision of Patent Law in 1992, the duration of patent protection of inventions was extended from 15 to 20 years and the duration of utility model and design patents was extended from 5 to 10 years; food, beverages, flavoring, pharmaceutical products, and substances obtained by means of chemical processes were also covered by patent protection, as well as adding the domestic priorities for filing applications. Individuals were allowed to own patents for invention-creations during work time if an agreement was made between individuals and employers. All these amendments inspired rapid growth in patent applications.

The third stage is from 2001 till now, where China’s patent Law experienced the second major revision in 2001. In this revision, state-owned and privately owned enterprises were treated as equals for obtaining patent rights. Other amendments were mainly made to fit the WTO requirement, especially those in TRIPs, for example, the simplification of examination process. This revision led to another surge in patent applications.

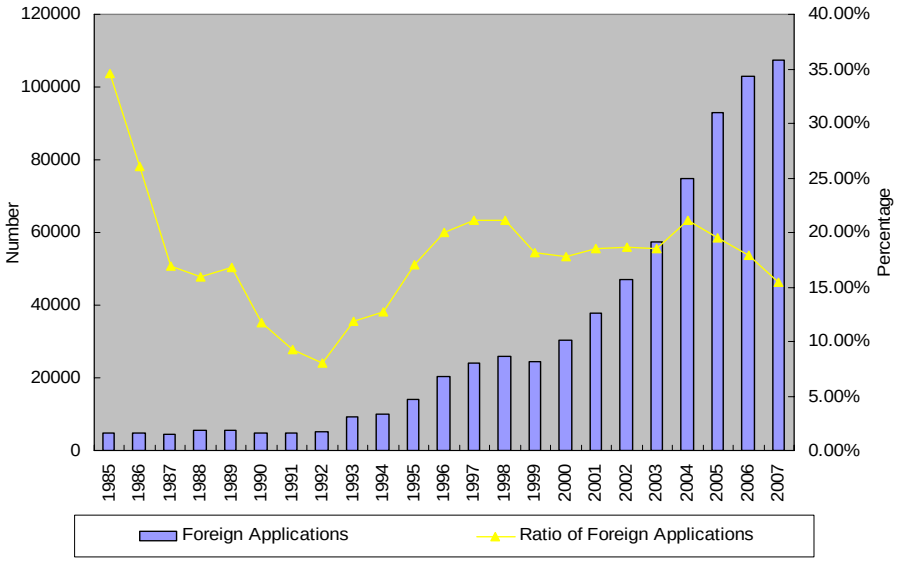
Ⅱ. A Comparison of Patenting Behaviors of Domestic and Multinational Companies in China

As discussed above, the evolution of patent system in China echoed the needs of different entities. Once it was founded, it will inevitably mould and affect the behaviors of these entities, although they may have totally opposite motivations. The observation of different behaviors by multinationals and domestic firms under the same patent system is one of the main concerns of this paper. In this section, we used the annual data issued by SIPO to examine their patent application, grant and validity in China, in order to disclose their innovative performance[9].

2.1 Sources of Patents

As Fig 3 reveals, after a lukewarm start for the first 5-6 years of China's patent system, foreign patent applications began to pick up after the first revision of patent law in 1992, which can be seen not only through the absolute numbers but also the percentage of foreign applications as the total applications. However, it seems that the second revision of patent law in 2000 induced fast increase of domestic and foreign applications simultaneously, which resulted in the stability of foreign application ratios since 2000 till 2003 and even the modest decreases in recent years after 2004. The different emphases of these two revisions may be the main cause.

Figure 3 Applications for Three Kinds of Patents Received from Abroad and its Ratio in Total Applications (1985-2007)

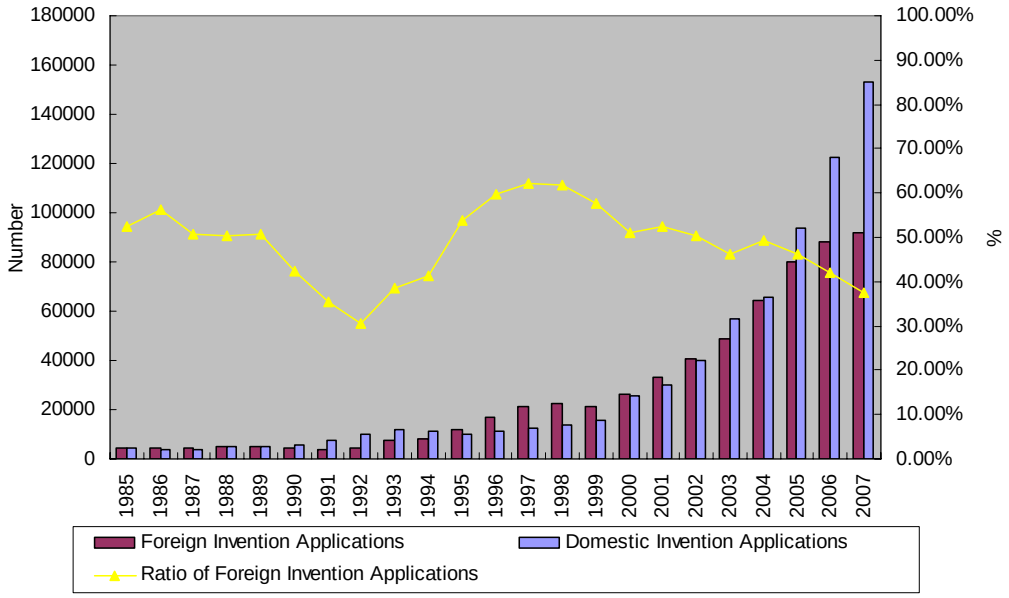


More interesting findings could be revealed when we pay attention to different kinds of patents. As introduced before, the main changes in 1992 Patent Law were extension of patent protection duration and expansion of patent protection scope, which coincided with the standards in most counties. It seems that this revision really inspired the enthusiasm of foreign applicants, especially for invention

[9] All the data used here are cited from SIPO Statistical Annals, if not indicated specially.

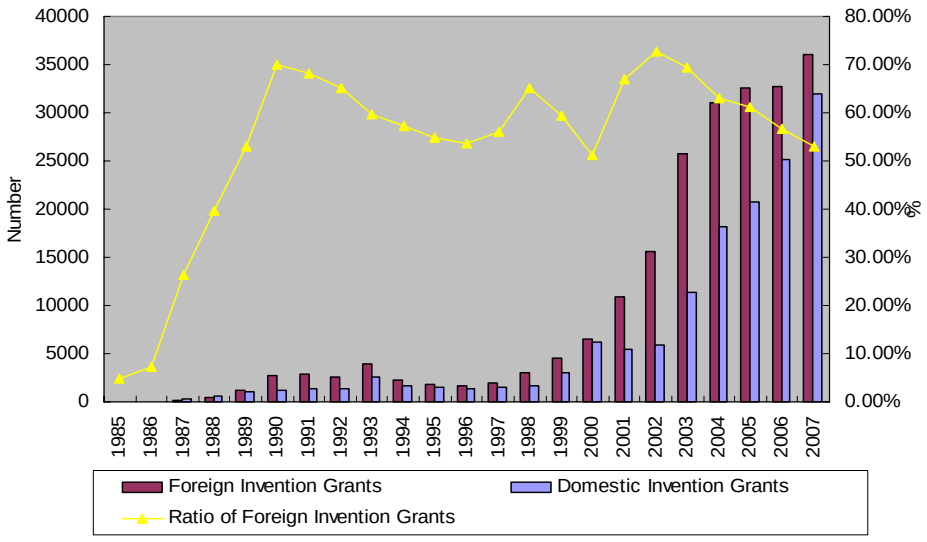
applications. As Fig 4 show, there were really a surge of foreign invention applications and its ratio in total invention applications reached the peak in 1997(62.24%). After that year, the domestic applications grew faster and surpassed foreign applications in 2003 despite the fact that foreign applications were still increasing.

Figure 4 Distribution of Annual Applications for Inventions Received from Home and Abroad (1985-2007)



But as to patent grants, even till now, the invention patents granted to foreigners are still higher than native, although the gap has narrowed quickly in past five years. From Fig 5 we can find distinct fluctuations on the invention grants during past 20 years. Especially, there appeared to be a several years' decrease of invention patent grants, right after the first revision of Patent Law. Furthermore, comparing to the drop of domestic grants, the decrease of foreign grants is faster, and it resulted in the first decrease of foreign ratios in total invention grants during 1990 to 1996.

Figure 5 Distribution of Annual Grants for Inventions Received from Home and Abroad (1985-2007)



As a comparison, if we look at the behaviors of foreign and domestic applications of utility model and design patents, we can find very big differences. As Table 1 depicts, since the patent system founded in China till nowadays, more than 99% applications for utility models, and more than 93% applications for designs are issued by domestic applicants. The same results could be found in granting side. It seems that the original design of three-tier patent system really acted, the 'petit patents' are mainly utilized by domestic players, which actually gave incentives to incremental innovations and the diffusion of knowledge.

Table 1 The Total Applications for Three Kinds of Patents Received from Home and Abroad (1985.4-2008.9) Unit: File

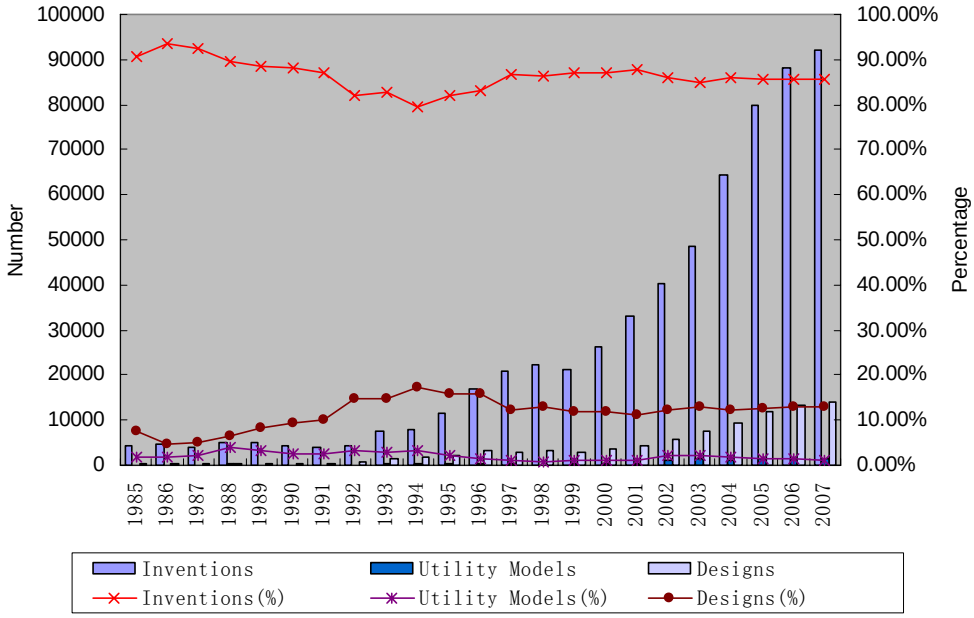
		Total		Invention		Utility Model		Design	
		Number	Ratio	Number	Ratio	Number	Ratio	Number	Ratio
Total	Sum	4576636	100.00%	1534934	100.00%	1623279	100.00%	1418423	100.00%
	In-service	2310455	50.50%	1184568	77.20%	516158	31.80%	609729	43.00%
	Non-service	2266181	49.50%	350366	22.80%	1107121	68.20%	808694	57.00%
Domestic	Sum	3780652	100/82.6	848390	100/55.3	1611467	100/99.3	1320795	100/93.1
	In-service	1545971	40.90%	522632	61.60%	507198	31.50%	516141	39.10%
	Non-service	2234681	59.10%	325758	38.40%	1104269	68.50%	804654	60.90%
Foreign	Sum	795984	100/17.4	686544	100/44.7	11812	100/0.7	97628	100/6.9
	In-service	764484	96.00%	661936	96.40%	8960	75.90%	93588	95.90%
	Non-service	31500	4.00%	24608	3.60%	2852	24.10%	4040	4.10%

Source: SIPO, http://www.sipo.gov.cn/sipo2008/ghfzs/zltj/zljb

2.2 Structure of Patents

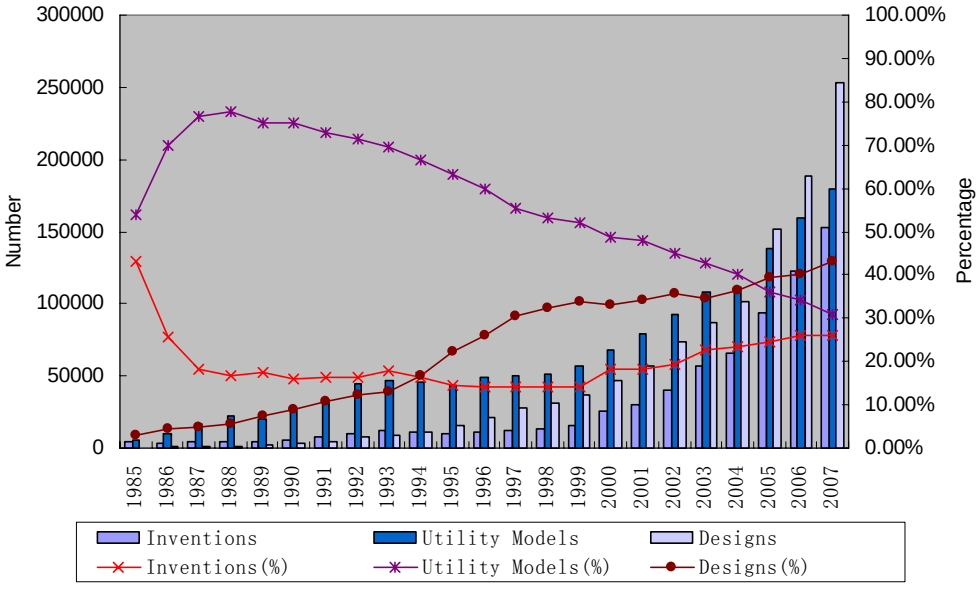
Fig 6 and Fig 7 give us a clearer scene on the different behaviors of foreign and domestic patent applicants. As Fig 6 depicts, the distribution of three kinds of patent applications issued by foreigners were very stable during past 23 years, and the invention applications were dominant. In most years, invention applications accounted for more than 85% of the total applications. We can also find another interesting phenomenon; foreign applicants seldom applied utility model patents, although it was regarded as 'part of inventions' by China's Patent Law. But they really applied quite a few design patents, although its ratio in total applications never exceeded 18% after reached its peak in 1994(17.42%). Even in 2007, the foreigners just submitted 1325 utility applications, no more than 14 times that they issued in 1985 (97). But during the same period, their invention applications in China expanded 20 times (4493 to 92101), and the design applications expanded nearly 38 times(371 to 13993).

Figure 6 Distributions of Annual Applications for Three Kinds of Patents Received from Abroad



As Fig 7 shows, the distributions of domestic patent applications are very different from foreign ones. Although in quite a long term, the utility models were dominant, its ratio in total applications began to decrease continuously even since 1988 after reached a peak (77.64%), due to the faster increase of invention and design applications, especially designs. As Fig 7 depicts, there really emerged a surge of invention applications since 2000, but the design applications increased more quickly. So, as a result, among all patent applications received from home in 2007, designs are dominant (43.21%), utility models rank the second (30.69%), inventions just account for 26.1%. Furthermore, the big changes of patent application structures in China are mainly caused by domestic players.

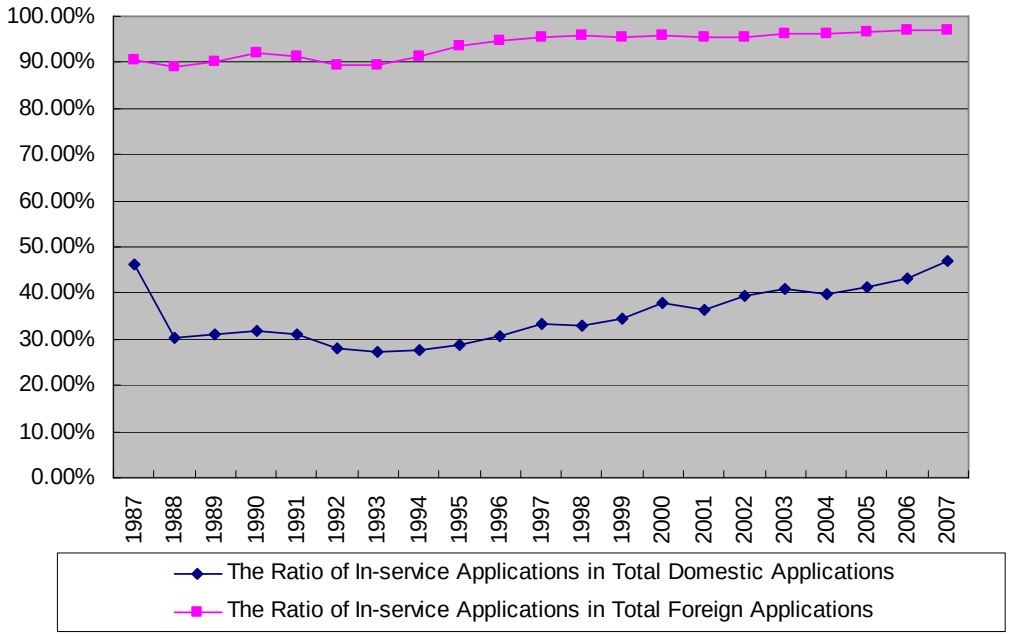
Figure 7 Distributions of Annual Applications for Three Kinds of Patents Received from Home



2.3 Character of Applicants

If we have more detailed investigation on the character of foreign and domestic applicants, we can also find major differences. As Fig 8 and Table 1 shows, In-service applications occupied absolute dominant situations in total applications received from abroad, and as we know, most of these applications are issued by multinationals. Besides, the ratios of In-service applications in total foreign applications during past 20 years were very stable and seldom fell under 90%, just as Fig 8 depicts. On the other side, the In-service applications hadn't exceeded 50% in annual domestic applications until 2007. What reason makes this difference? If we divide all the applications into three kinds of patents, maybe the answer could be a little clear. As Table 1 shows, there aren't distinct differences among In-service application ratios for three kinds of patent issued by foreigners, except the relatively low ratios for utility models (75.90%). As we found before, the annual quantities of foreign applications for utility models were much lower than the other two kinds of patents. It seems that multinationals didn't care about utility models. On the other side, we can observe nearly total opposite behaviors of domestic applications for different kinds of patents. Among total domestic applications for inventions, more than 60% were In-service. But for utility models, this ratio just exceeds 30%, and for designs, the ratio is nearly 40%. So we can conclude, even till now, most of the 'Petit Patents' in China is developed by domestic individuals, not the firms and other organizations.

Figure 8 Comparisons of the Ratios of Domestic and Foreign In-service Patent Applications



2.4 Patent Validity

As we know, once a patent was granted, the patentee must pay annual fees to maintain

the validity of this patent. Generally said, the patentee will pay this fee only when he estimates the return from this patent will exceed the cost to maintain it. So, we can partially estimate the quality and value of one patent from its validity. As Table 2 depicts, till the end of 2007, among all granting patents by SIPO in past 23 years, only 40% were still valid (in force). The valid ratios of three kinds of patents granted to foreigners are all higher than the ones granted to domestic patentees. The gap on inventions is not very big (66% to 80%), comparing to the huge ones on utility models and designs. These gaps revealed a fact, although the domestic applications and grants of 'Petit Patents' grew very fast in China and attributed to the total increase of patents, their qualities were still poor, comparing to the same kind of patents hold by foreigners. Quite a lot 'Petit Patents' were given up by the patentees themselves after a short term of maintaining. From Table 2 we can also found that, whether foreign or domestic, the valid ratios of invention patents are highest. It approved the potential high value of inventions again.

Table 2 Total Applications/Grants/In Force for Three Kinds of Patents Received from Home and Abroad(1985.4 - 2007.12) Unit: File

		Total		Invention		Utility Model		Design	
		Number	%	Number	%	Number	%	Number	%
Total	Application	4028284	100.00%	1334676	33.10%	1471191	36.50%	1222417	30.30%
	Grant	2089286	100.00%	364451	17.40%	988264	47.30%	736571	35.30%
	In Force	850043	100.00%	271917	32.00%	299242	35.20%	278884	32.80%
	Grant/Application		51.87%		27.31%		67.17%		60.26%
	In Force/Grant		40.69%		74.61%		30.28%		37.86%
Domestic	Application	3314355	82.30%	718207	21.70%	1460557	44.10%	1135591	34.30%
	Grant	1790379	85.70%	144387	8.10%	980029	54.70%	665963	37.20%
	In Force	622409	73.20%	95678	15.40%	294463	47.30%	232268	37.30%
	Grant/Application		54.02%		20.10%		67.10%		58.64%
	In Force/Grant		34.76%		66.26%		30.05%		34.88%
Foreign	Application	713929	17.70%	616469	86.30%	10634	1.50%	86826	12.20%
	Grant	298907	14.30%	220064	73.60%	8235	2.80%	70608	23.60%
	In Force	227634	26.80%	176239	77.40%	4779	2.10%	46616	20.50%
	Grant/Application		41.87%		35.70%		77.44%		81.32%
	In Force/Grant		76.16%		80.09%		58.03%		66.02%

Source: SIPO Patent Statistical Annals, 2007.

Ⅲ. Innovative Performance of Domestic Firms: Evaluation by Patent Data

As introduced, we choose 500 China's biggest corporations in 2006 as our population of investigation. During past 20 years, sampled domestic firms have applied for

totally 16109 inventions in China. Figure 9 presents annual number of domestic sample firms' invention applications. As it depicts, before the year 1999, there were rarely any invention applications. The first round of patent law amendment in some degree boosted domestic firms' invention application activities but it was not evident enough. After 2000, with the second round of patent law amendment, domestic firms' innovation motivation increased obviously. Especially in the year 2002, there were totally 3625 invention applications, increasing by 92% than the previous year.

Figure 9 Invention Applications of Domestic Sample Firms (1985-2004)

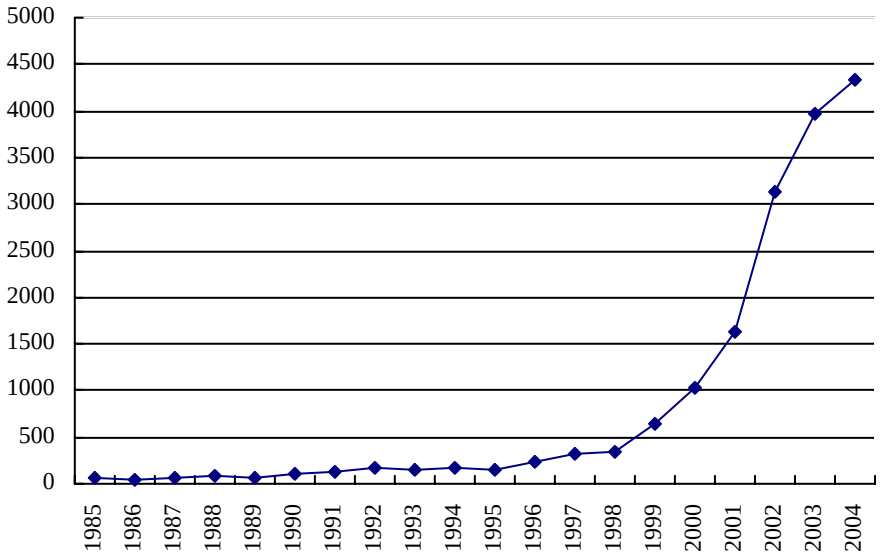


Table 3 presents the province distribution of domestic sample firms' invention application. Beijing, Guangdong and Shanghai are the three provinces with most invention applications, taking up over four fifth of the total applications.

Table 3 Province Distribution of Domestic Sample Firms' Invention Application (First 10)

Province	Invention application	Percentage	Accumulative Percentage
Beijing	6586	39.08	39.08
Guangdong	6544	38.83	77.90
Shanghai	917	5.44	83.35
Shandong	552	3.28	86.62
Liaoning	341	2.02	88.64
Jiangsu	277	1.64	90.29
Hubei	240	1.42	91.71
Sichuan	226	1.34	93.05
Hunan	166	0.98	94.04
Hebei	160	0.95	94.99

Table 4 lists domestic firms with over 200 invention application during the 20 years. Huawei Technology Ltd. applied for 5365 inventions, ranking first of all, taking up as high as 33.3% of the overall invention applications. China Petroleum and Chemical Group, Lenovo Ltd., and ZTE Corporations follow Huawei Technology. These five corporations applied for more than 60% of the overall inventions in China, which reflected the domestic invention applications are highly concentrated and the main

players are just several large corporations. As Table 3 and Table 4 reflect, innovation of China's domestic firms is limited to a few firms, in a few industries, and a few regions.

Table 4 Domestic Sample Firms with over 200 Invention Applications

Patentee	Industry	Invention application	Percentage	Accumulative percentage
Huawei Technology Ltd.	IT	5365	33.30	33.30
China Petroleum and Chemical Ltd.	Chemicals	2093	12.99	46.30
China Petroleum and Chemical Group	Chemicals	782	4.85	51.15
Lenovo Ltd.	IT	745	4.62	55.78
ZTE Corporation	IT	739	4.59	60.36
China Petroleum and Chemical Corporation	Chemicals	458	2.84	63.21
PetroChina Company Limited	Chemicals	346	2.15	65.35
Baosteel Ltd.	Steel	325	2.02	67.37
Haier Ltd.	Household Durables	256	1.59	68.96

Figure 10 demonstrates invention applications of the top five firms listed in above, in comparison with the total applications of sample firms. Before 1998, these firms had rarely any patent applications. During 1999 to 2002, the share of invention applications by top five firms kept rising, taking up to 80% of overall annual applications. After 2002 however, these top five firms slowed down their application paces and was outstripped by other firms, which may means the growth of other domestic firms.

Figure 10 Invention Applications of Domestic Top 5 Firms (1985-2004)

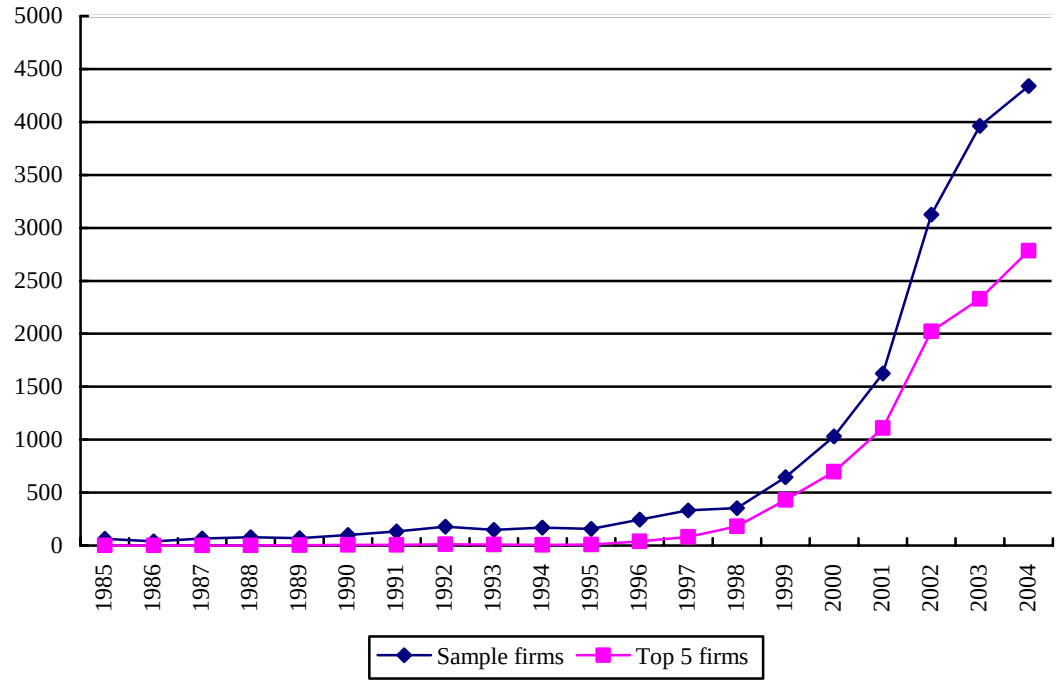


Table 5 lists the IPC subclass distribution of sample firms' invention applications (above 200 files). We can observe that H04L (Transmission of digital information, e.g. Telegraphic communication), H04Q (Selecting), G06F (Electric digital data processing), C10G (Cracking hydrocarbon oils; production of liquid hydrocarbon mixtures, e.g. by destructive hydrogenation, oligomerisation, polymerisation), B01J (Chemical or physical processes, e.g. Catalysis, colloid chemistry; their relevant apparatus) are the concentrated areas of invention applications which take up 45.21% of the overall applications.

Table 5 IPC Subclass Distribution of Domestic Sample Firms' Invention Applications (Above 200 files)

IPC Subclass Number	IPC Subclass	Invention Applications	Percentage	Accumulative Percentage
H04L	Transmission of digital information, e.g. Telegraphic communication	2675	16.61	16.61
H04Q	Selecting	1595	9.90	26.51
G06F	Electric digital data processing	1120	6.95	33.46
C10G	Cracking hydrocarbon oils; production of liquid hydrocarbon mixtures, e.g. By destructive hydrogenation, oligomerisation, polymerisation	1067	6.62	40.08
B01J	Chemical or physical processes, e.g. Catalysis, colloid chemistry; their relevant apparatus	826	5.13	45.21
H04J	Multiplex communication	726	4.51	49.72

H04B	Transmission	598	3.71	53.43
C07C	Acyclic or carbocyclic compounds	570	3.54	56.97
H04M	Telephonic communication	539	3.35	60.31
C08F	Macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds	396	2.46	62.77
H04N	Pictorial communication, e.g. Television	368	2.28	65.06
C01B	Non-metallic elements; compounds thereof	274	1.70	66.76
G01N	Investigating or analyzing materials by determining their chemical or physical properties	251	1.56	68.32
C22C	Alloys	226	1.40	69.72

Table 6 lists the five top IPC subclass classifications of each top five corporations listed in Table 4. We can find that each top corporation's inventions are highly concentrated on limited number of IPC subclasses. Generally, the top five categories of IPC subclasses take up 70% to 80% of the overall invention application of the very corporation.

Table 6 IPC Subclasses Distribution of Domestic Sample Firms (Top Five)

IPC Subclass Number	IPC subclass	Invention Application	Percentage	Accumulative percentage
Huawei				
H04L	Transmission of digital information, e.g. Telegraphic communication	2107	39.27	39.27
H04Q	Selecting	1134	21.14	60.41
H04J	Multiplex communication	496	9.25	69.66
G06F	Electric digital data processing	390	7.27	76.92
H04B	Transmission	385	7.18	84.10
SINOPEC[10]				
C10G	Cracking hydrocarbon oils; production of liquid hydrocarbon mixtures, e.g. By destructive hydrogenation, oligomerisation, polymerization	921	27.63	27.63
B01J	Chemical or physical processes, e.g. Catalysis, colloid chemistry; their relevant apparatus	669	20.07	47.70
C07C	Acyclic or carbocyclic compounds	421	12.63	60.34
C08F	Macromolecular compounds obtained by reactions only	279	8.37	68.71

[10] Including China Petroleum and Chemical Ltd., China Petroleum and Chemical Group, China Petroleum and Chemical Corporation

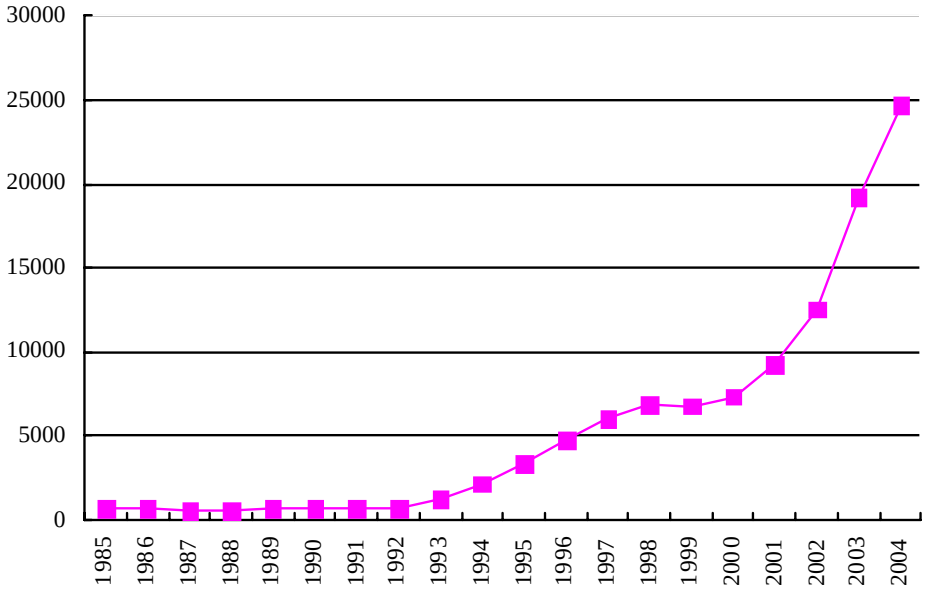
	involving carbon-to-carbon unsaturated bonds			
C01B	Non-metallic elements; compounds thereof	184	5.52	74.23
Lenovo				
G06F	Electric digital data processing	454	60.94	60.94
H04L	Transmission of digital information, e.g. Telegraphic communication	129	17.32	78.26
H04M	Telephonic communication	30	4.03	82.28
H04Q	Selecting	26	3.49	85.77
H04N	Pictorial communication, e.g. Television	19	2.55	88.32
ZTE				
H04L	Transmission of digital information, e.g. Telegraphic communication	179	24.22	24.22
H04Q	Selecting	152	20.57	44.79
H04J	Multiplex communication	128	17.32	62.11
G06F	Electric digital data processing	63	8.53	70.64
H04B	Transmission	63	8.53	79.16
PetroChina				
C10G	Cracking hydrocarbon oils; production of liquid hydrocarbon mixtures, e.g. By destructive hydrogenation, oligomerisation, polymerization	41	11.85	11.85
C08F	Macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds	35	10.12	21.97
C10M	Lubricating compositions; use of chemical substances either alone or as lubricating ingredients in a lubricating composition	31	8.96	30.92
C07C	Acyclic or carbocyclic compounds	29	8.38	39.31
B01J	Chemical or physical processes, e.g. Catalysis, colloid chemistry; their relevant apparatus	24	6.94	46.24

Comparing Table 6 with Table 5, we can find that the IPC subclass distributions of top domestic firms' invention applications are very similar to the IPC subclass distributions of all domestic samples, which reflect China's domestic invention applications are highly concentrated in several firms which invention categories have great influences on domestic firms' invention category distribution. For example,

Huawei has applied for 2107 inventions in the H04L subclass, taking up nearly 40% of its total application, which also accounts for 78.8% of the overall invention applications in that subclass issued by all sample firms.

Ⅳ. Innovative Performance of Multinational Companies: Evaluation by Patent Data

Similar to the sample in above, we use Fortune Global 500 list (2006) as our population of foreign companies. During past 20 years (1985-2004), foreign sample



companies have applied for totally 108747 inventions in China, about 10 times of the applications issued by domestic sample firms in total. Figure 11 presents annual number of foreign sample firms' invention application. As it depicts, multinational companies' invention applications in China have two upsurges, the first around 1993 and the second around 2001. After 1993, foreign applications increased by over 50% annually. From 1997 to 2000, their applications accelerated moderately and even decreased in 1999. And after the second upsurge from 2002 to 2004, totally 56432 inventions were applied for, taking up over 50% of the overall applications.

Figure 11 Invention Applications of Foreign Sample Firms (1985-2004)

Figure 12 compares the invention applications of domestic firms and foreign firms in China. It is obvious that before 2000, there was huge gap between the two groups. Applications of domestic firms are less than 1/15 of that of foreign firms, which reflects the huge technology gap. After 2000, however, domestic firms' applications increased dramatically and reached 1/5 of foreign firms', which also indicates the domestic innovative capabilities increased very fast.

Figure 12 Invention Applications of Domestic Sample Firms and Foreign Sample Firms （1985-2004）

With regard to parent country distribution, Japanese companies ranks first as many as 50779 files totally, taking up 46.7%; US companies ranks second as many as 24001 files, taking up 22.1%; Korean companies ranks third as many as 13115 files, taking up 12.1%; Netherlands and Germany companies rank respectively fourth and fifth. The companies from these five countries applied for over 95% of the total foreign inventions.

Figure 13 describes annual invention applications of the above five countries during 1985 and 2004. As it depicts, before 1993, there were rarely any invention applications. Korean firms applied for their first invention in 1989, indicating their lateness in entering China's market. After 1993, Japanese firms applied for more and more inventions every year in accelerating speed. Comparatively, U.S. firms' applications accelerated rather moderately. It is also interesting to notice that German firms' invention applications decreased these years.

Figure 13 Annual Invention Applications of the Sample Companies from Top Five Countries (1985-2004)

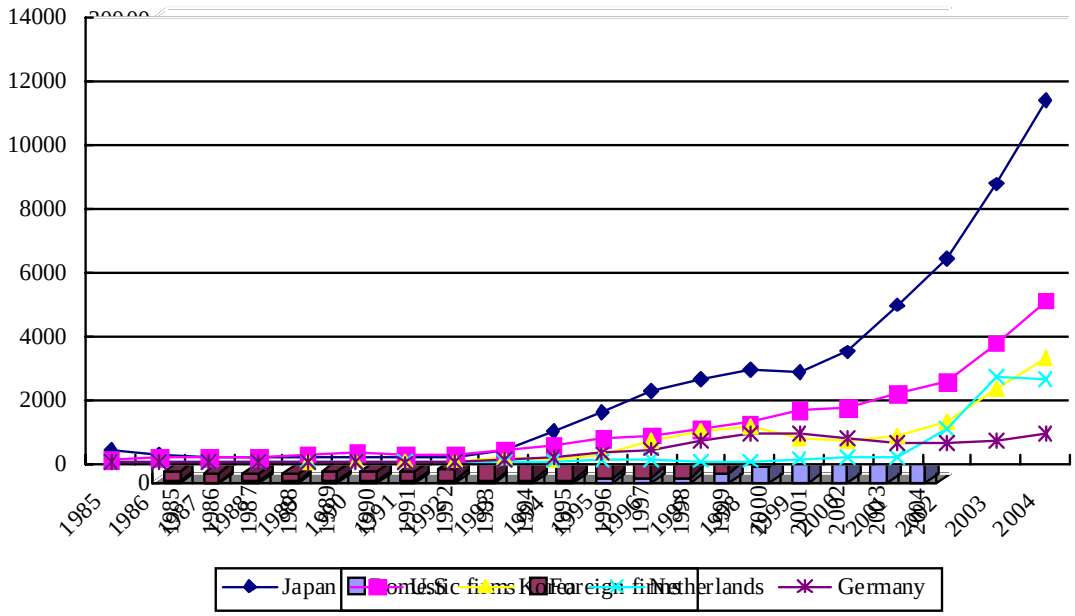


Table 7 lists foreign firms with over 1000 invention applications during 1985 to 2004. Panasonic from Japan applied for 12644 inventions, ranking first of all, taking up 11.63% in overall applications; Samsung ranks second as many as 9998 files, taking

up 9.19%; Philips ranks third as many as 5586 files, taking up 5.14%. And out of the top five multinational companies, five are from Japan, two from U.S., and one respectively from Korea, Netherlands and Germany. Generally, the applications of Japanese companies are more concentrated, comparing with U.S firms. Samsung, Philips, and Simense all composed a large amount of the total applications of their parent countries.

Table 7 Foreign Firms with over 1000 Invention Applications

Patentee	Parent Country	Invention Application	Percentage	Accumulative Percentage
Panasonic	Japan	12644	11.63	11.63
Samsung	Korea	9998	9.19	20.82
Philips	Netherlands	5586	5.14	25.96
Simense	Germany	4713	4.33	30.29
Mitsubishi	Japan	4454	4.10	34.39
IBM	U.S	4119	3.79	38.17
Canon	Japan	4117	3.79	41.96
Sony Electronics	Japan	3832	3.52	45.48
Sanyo Electronics	Japan	3122	2.87	48.36
Motorola	U.S	2769	2.55	50.90
Sony	Japan	2762	2.54	53.44
Honda	Japan	2559	2.35	55.79
Intel	U.S	2199	2.02	57.82
Dupont	U.S	2183	2.01	59.82
GE	U.S	2135	1.96	61.79
Fujitsu	Japan	2060	1.89	63.68
P&G	U.S	1817	1.67	65.35
3M	U.S	1557	1.43	66.78
Shell	Holland	1458	1.34	68.13
Sharp	Japan	1424	1.31	69.43
Microsoft	U.S	1011	0.93	70.36
Sumitomo Chemical	Japan	1009	0.93	71.29

Comparing the patentee distribution of foreign firms with that of domestic firms, we can find much more concentration for domestic firms. For example, only Huawei Technology one company takes up 1/3 of domestic applications while top five foreign firms take up the same percentage of foreign applications.

Table 8 describes the IPC subclasses distribution of foreign sample firms' invention applications (above 2000 files). From which we can find that G06F (Electric digital data processing), G11B (Information storage based on relative movement between record carrier and transducer), H04N (Pictorial communication, e.g. Television), H01L (Semiconductor devices; electric solid state devices not otherwise provided for), and H04L (Transmission of digital information, e.g. Telegraphic communication) are

the main subclasses of foreign firms' invention applications. These five subclasses account for as many as 29.11% of foreign sample firms' total inventions applications. And if we compare Table 8 with Table 5, we can find that the IPC distribution of foreign sample firms is quite similar to that of domestic firms except fewer differences in chemical category, which means that there are really competitions between multinationals and China's leading domestic companies, especially in certain areas such as telecommunication.

Table 8 IPC Subclasses Distribution of Foreign Sample Firms (Above 2000 files)

IPC Subclass Number	IPC subclass	Invention Applications	Percentage	Accumulative percentage
G06F	Electric digital data processing	8320	7.65	7.65
G11B	Information storage based on relative movement between record carrier and transducer	7064	6.50	14.15
H04N	Pictorial communication, e.g. Television	5971	5.49	19.64
H01L	Semiconductor devices; electric solid state devices not otherwise provided for	5450	5.01	24.65
H04L	Transmission of digital information, e.g. Telegraphic communication	4856	4.47	29.11
H04Q	Selecting	3801	3.50	32.61
H04B	Transmission	3204	2.95	35.56
H01M	Processes or means, e.g. Batteries, for the direct conversion of chemical energy into electrical energy	2182	2.01	37.56
H01J	Electric discharge tubes or discharge lamps	2137	1.97	39.53
G03G	Electrography; electrophotography; magnetography	2055	1.89	41.42

The patent data analysis also reveals that, during past 20 years, 104091 files out of the total 108747 invention applications issued by foreign companies have priorities, taking up nearly 96% of overall applications, which means most of foreign companies' invention applications in China have been applied in abroad before, most likely in their home countries. It also confirms Hu's speculation that when foreign companies bring forward invention applications to SIPO, they do not need to wait for the technologies to be perfect but rather the market being ready. It is likely that multinationals in these foreign countries are patenting a larger proportion of their existing inventions in China (Hu, 2006). Another research performed by our team also proved this (Zhu&Liang, 2006).

Ⅴ. Conclusion

As the patent data reflect, multinational companies' innovative performance exceeds the China's domestic firms faraway, either in quantity or in quality. Most of their patent applications are inventions, in-service applications and have higher granting and valid ratios, which makes distinct contrast to domestic applications. But multinationals' patent applications in China are mainly regarded as competition tools oriented on market thinking instead of representative of their actual and holistic innovative capabilities. They use China's patent system to provide them with strategic competitive advantage rather than to gain monopoly rent from their technological advantage. But at the same time, their patent applications in China not only inspire the "patent competition" in corresponding areas, but also give the chance for domestic firms to imitate and "invent around". Some empirical studies reveal that there are correlations between foreign invention applications and domestic utility/design applications, which partly proved this (Liu et al., 2003; Hu, 2006).

Local firms also adapted to China's patent system through gradual innovation, taking advantage of the two kinds of minor innovation. But most of Chinese firms have not been able to become true innovators in their corresponding industries, as evidenced by the lower invention granting ratio, with a few exceptions such as Huawei. Besides, although there emerged domestic patent surge recent years, their understanding of patent and patent strategies is still at the early stage. The small quantities and low concentration of leading firms on domestic invention applications partially revealed this. Especially, the low-level orientations on innovations and pervasively following and imitating behaviors among domestic firms may also harm the cultivation of their long-term and core competences.

However, accompanied with China's domestic firms' growth, the innovative performance of the two groups may also converge. Huawei's story is a typical case. In fact, Cisco's litigation directly stimulated the formulation of Huawei's IPR Strategy. Huawei founded the pre-research department which includes more than 1000 persons and gave more emphasizes on the cutting-edge technology research. At the same time, it strengthened patent analysis and concentrated on the breakthrough of technologies with comparative advantages, such as WCDMA. It improved collaborations with multinationals and founded strategic partnerships with most of the industry peers, such as 3Com and Simense, and make every efforts to obtain technologies through licensing and M&A. It also actively participated in the process of international standards establishment and became members of 83 standardization organizations. And finally as the result, the accumulative patent applications of Huawei reached 29666 by June 2008[11]. It also became the 4th largest patent applicant under the WIPO PCT, with 1,365 applications published in 2007, just

[11] Source, http://www.huawei.com/corporate_infomation/research_development.do.

behind Matsushita, Philips and Siemens[12]. Huawei followed a competitive strategy not only relying heavily on IPR protection of the core technologies, but also using its own technological advantage to integrate global innovation resources. During this process, Huawei developed new collaborative relationships with multinationals, whose roles also changed towards Huwei: first as "teachers", then as competitors, and finally as collaborators, which had become a typical road of China's domestic leading companies such as Lenovo, Cherry etc.

[12] WIPO, Unprecedented Number of International Patent Filings in 2007, Geneva, February 21, 2008. Source,http://www.wipo.int/pressroom/en/articles/2008/article_0006.html.

Reference

[1] Alford, W.P., 1995. To Steal a Book is an Elegant Offense: Intellectual Property Law in Chinese Civilization, Stanford, CA: Stanford University Press.

[2] Arrow, K.J., 1962. Economic welfare and the allocation of resources for invention, in: Nelson, R.R. (Ed.) The Rate and Direction of Inventive Activity. New York: Princeton University Press.

[3] Blind, K., Elder, J., Frietsch, R. and Schmoch, U., 2004. Scope and nature of the patent surge: a view from Germany. Patents, Innovation and Economic Performance, Paris: OECD.

[4] Bruun, P., Bennett, D., 2002. Transfer of Technology to China:A Scandinavian and European Perspective. European Management Journal, 20(1), 98–106.

[5] Chen, X., Sun, C., 2000. Technology transfer to China: alliances of Chinese enterprises with western technology exporters. Technovation, 20, 353–362.

[6] Commission on Intellectual Property Rights, 2002. Integrating intellectual property rights and development policy. London, UK: Commission on Intellectual Property Rights.

[7] Ernst, H., 2001. Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. Research Policy, 30, 143-157.

[8] European Union Chamber of Commerce in China, 2005. “European Business in China – Position paper 2005”, Beijing.

[9] Funk, J.L., 1998. Competition between Regional Standards and the Success and Failure of Firms in the World-wide Mobile Communication Market. Telecommunications Policy, 22(4/5), 419～441.

[10] Green, J., Scotchmer, S., 1995. On the division of profit in sequential innovation. RAND Journal of Economics 26, 20-33.

[11] Greguras, F.,2007. Intellectual property strategy and best practices for R&D services in China. Computer Law& Security Report, 23, 449-452.

[12] Guvenli, T. and Sanyal R. 2003. Perception and Management of Legal Issues in China by US firms. Journal of Socio-Economics, 32, 161–181.

[13] Hippel, V., 1988. The Sources of Innovation. New York: Oxford University Press.

[14] Hu, A., 2006., What and Why Do They Patent in China? Workshop on Greater China’s Innovative Capacities: Progress and Challenges. Mimeo, Beijing: Tsinghua University.

[15] Hu, A and Jefferson, G., 2001. FDI , Technology innovation and Spillover : Evidence from large and medium size Chinese enterprises, Mimeo, Brandeis University.

[16] Liang, Z. and Xue, L., The Evolution of China’s IPR System and Its Impact on the Patenting Behaviors and Strategies of Multinationals in China, International Journal of Technology Management, 2010(forthcoming)

[17] Liu, Y., Xia, M., and Wu, X., 2003, Measurement Research on Patent of Chinese Top 500 Foreign Investment Corporations and its Influence. Forecasting, 22(6), 19-23. (In Chinese)

[18] Lu, F. and Feng, K., 2005. Policy choices on developing China’s Automobile Industry with Endogenous IPRs, Beijing: Peking University Press (in Chinese).

[19] Macdonald S., 2004. When means become ends: considering the impact of patent strategy on innovation. Information Economics and Policy, 16: 135-158.
[20] Machlup, F., 1958. An Economic Review of the Patent System. Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, U.S. Senate, 85th Congress, Washington, DC: Government Printing Office.
[21] Mazzoleni, Nelson R., 1998. The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate. Research Policy 27, 273-284.
[22] Merges, R., Nelson, R., 1990. On the complex economics of patent scope. Columbia Law Review 90 (4), 839–916.
[23] Nordhaus, W.D., 1962. Invention, Growth, and Welfare. A Theoretical Treatment of Technological Change. MIT Press, Cambridge, MA.
[24] OECD, 2008. OECD Reviews of Innovation Policy CHINA, Paris: OECD Publications.
[25] OECD, 2005. “Intellectual Property Rights in China: Governance Challenges and Prospects”, in OECD. Governance in China, Paris: OECD, 403-432.
[26] Potter, P.B. and Oksenberg, M.,1999. A Patchwork of IPR Protections. The China Business Review, 26(1).
[27] Scherer, F.M., 1972. Nordhaus's theory of optimal patent life: a geometric reinterpretation. American Economic Review 62, 422-427.
[28] Scotchmer, S., Green, J., 1990. Novelty and disclosure in patent law, RAND Journal of Economics 21, 131-146.
[29] Simone, J.,1999, China’s IPR Enforcement Mechanism. The China Business Review, 26(1).
[30] Sun, Y., 2003. Determinants of foreign patents in China. *World Patent Information* 25, 27–37.
[31] Wang, J. and Liang, Z., 2007. An Advocacy Coalition Approach to Global Governance on Technology Standard Evolution: The Case of WLAN Standards, Proceedings of 2007 International Conference on Public Administration (3rd ICPA), Vol I: 1115-1122.
[32] World Bank, 2003. World Development Report 2003: Sustainable Development in a Dynamic World, World Bank and Oxford University Press, New York, NY.
[33] Xue, L. and Liang, Z., 2008. Multinational R&D in China: Myths and Realities, in Rowen, H.(Eds.) Greater China's Quest for Innovation, Stanford, CA: Walter H. Shorenstein Asia-Pacific Research Center: 103~122.
[34] Zhu, X. and Liang, Z., 2006. Patenting behavior of MNCs in China: an analysis based on panel data, 15th International Conference on Management of Technology (IAMOT 2006), ‘East Meets West: Challenges and Opportunities in Era of Globalization’, Beijing, May 22-26,2006.
[35] Zhou Z., Zhong H., Li J.,2006. Analysis on automobile MNCs' control over China's joint ventures. China's Foreign Trade, 12: 20-22.(in Chinese)