

Recent China's Patent Activity and Innovation Capacity

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Abstract

Recently, patent applications of Chinese innovative entities have been increasing and approved patents have been increasing, so attention has been focused. It shows that China's innovators rapidly increasing their capacity. This study describes the increase in patent activity and investigates the background of increased patent activity in China. The results can be summarized as follows. Firstly, China has evolved into a system in which local governments lead innovation activities with strong motivations and patent activities are increasing around local governments. Secondly, as China has pushed forward indigenous innovation policy and has an innovation system friendly to domestic firms, the patent activity of Chinese firms has far exceeded that of foreign-invested firms in China.

Keywords: *China; Patent Activity; WIPO; Local Government; Indigenous Innovation*

1. Introduction

Recently, patent applications of Chinese innovator have been increasing and approval patents have been increasing, so attention has been focused. According to the World Intellectual Property Organization (WIPO) report in 2019, the China National Intellectual Property Administration (CNIPA) received 55,211 applications for PCT in 2018 alone, the second largest number of patent applications in the world after the U.S. Patent and Trademark Office (USPTO), which received 55,330 applications for PCT. The number of applications for PCT patents by an applicant residing in China to 53,345, the second position after the U.S. with 56,142.

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Until 2016, the number of patent applications for PCT by innovative entities residing in Japan was the second-largest in the world, but the number of patent applications by Chinese innovators exceeded that.

Table1: China’s business entities in 2018 Patent application Top 50 business entity

	Change	Corporation	PCT patent application		
			2016	2017	2018
1	0	Huawei Tech. Co. LTD	3692	4024	5405
5	-3	ZTE Corporation	4123	2965	2080
7	0	BOE Tech. Group Co. LTD.	1673	1818	1813
17	23	Guangdong OPPO MOBILE Tele. CORP., LTD.	80	474	1042
28	4	TENCENT TECH. (Shenzhen) CO. LTD.	172	560	661
29	56	SZ DJI TECHNOLOGY CO., LTD	197	241	656
39	-22	Shenzhen CSOT CO., LTD	1163	972	463
49	19	WUHAN CSOT CO., LTD	86	290	395

Source: WIPO PCT Yearly Review (2019, p. 35)

In particular, Chinese firms' patent applications are notable. Huawei was ranked as the world's largest patent-applicant the one the year of 2018, with PCT patents nearly twice as much as No. 2 Mitsubishi. As shown in Table 1, eight Chinese firms were included in the top 50 list of firms with high patent applications from 2016 to 2018. Huawei is ranked second after Panasonic on the list of companies that applied for many patents from 1978 to 2018 (WIPO, 2019).

It shows that China's innovators rapidly increasing their capacity. The "Made in China 2025" plan, announced in 2015, aims to increase the share of R&D spending to manufacturers' sales by 1.26 percent in 2020, 1.68 percent in 2025, and increase the number of inventions per 100 million yuan in manufacturers' sales by 0.7 in 2020 and 1.1 in 2025. To that end, Chinese firms are spending a lot of R&D expenditure to create innovations.

The ultimate goal of the race in these efforts is to enhance China's innovative competitiveness. Such China's goal-setting and actual rise are expected to have a great impact on the global economy. In particular, it can have a great impact on industry and employment in many countries around the world. Therefore, it is worth studying in depth from various points of view on increasing the patent activities of Chinese innovators and enhancing innovation capabilities.

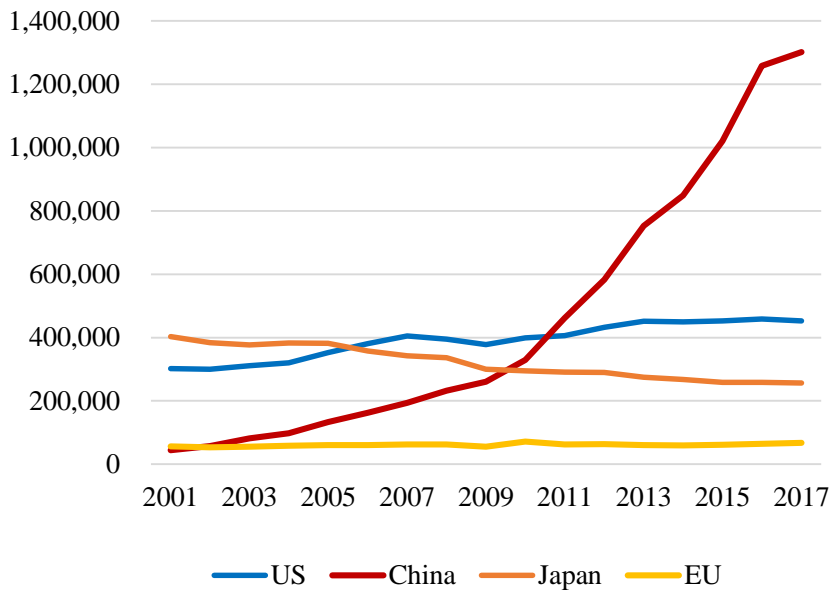
In this background, this paper analyses China's rapidly increasing patent applications and examines whether the use of patent assets by Chinese innovators can be linked to enhancing innovation competitiveness. China has a strong incentive for innovators to acquire internal patent applications, so the phenomenon of increased patent applications and the enhancement of innovative competitiveness may have a weak direct relationship. Section 2 analyzes China's recent patent phenomenon. Section 3 analyzes the transformation of innovation system centered on local government and the motivation of the patent application of local government. Section 4 analyzes the changing status of foreign-invested firms and the increase of innovation capacity of Chinese domestic firms. Section 5 summarizes the analysis results and summarizes the conclusions.

2. China's recent patent activity increase

Above all, we need to take a closer look at China's growing patent applications. According to Kashcheva, Wunsch-vincent and Zhou (2014), which analyzed China's patent phenomena, Chinese innovators have been very active in acquiring patent applications abroad in the 2000s, especially recently, and the percentage of patent applicants to the Chinese patent authorities has also increased significantly compared to non-residents. Both the number of patents held by innovators residing in abroad registered with the Chinese patent authorities and those held by innovators residing in China are rapidly increasing. However, many of Chinese domestic patent applications are patent for utility models. In addition, while the number of patent applications in China is increasing, the number of overseas patent applicants is concentrated in several firms and institutes (Kroll, 2011; Eberhardt, Helmers and Yu, 2014).

A closer look at the analysis of Santacreu and Zhu (2018) shows that the increase in Chinese patent applications is very noticeable, but in three respects it has different characteristics from those of other developed countries. The first is that for PCT international applications, the patent approval rate is lower than in other developed countries. Based on the 2000-2016 statistics, the approval success rate stood at 23.44 percent, lower than that of Germany at 43.5 percent and the U.S. at 44.93 percent. Second, China's patent applications are mostly focused on utility model patents rather than invention patents (19.3 percent), so their innovation is relatively low. Third, most of China's patent-applicants focus on domestic patent applications and do not obtain patents from foreign countries, with only 4.17 percent of patents filed in China in 2016. Of the patents approved in China, only 6.31 percent have obtained patents in foreign countries. This is a huge difference compared to 48.1 percent of patents obtained in the U.S. that were also obtained in foreign countries. In other words, China's patent application and acquisition activities are competing for the world's top position in terms of quantity, but in terms of content, they have yet to reach the level of advanced countries in the world.

Figure 1: Number of applications received for direct patent by the economy



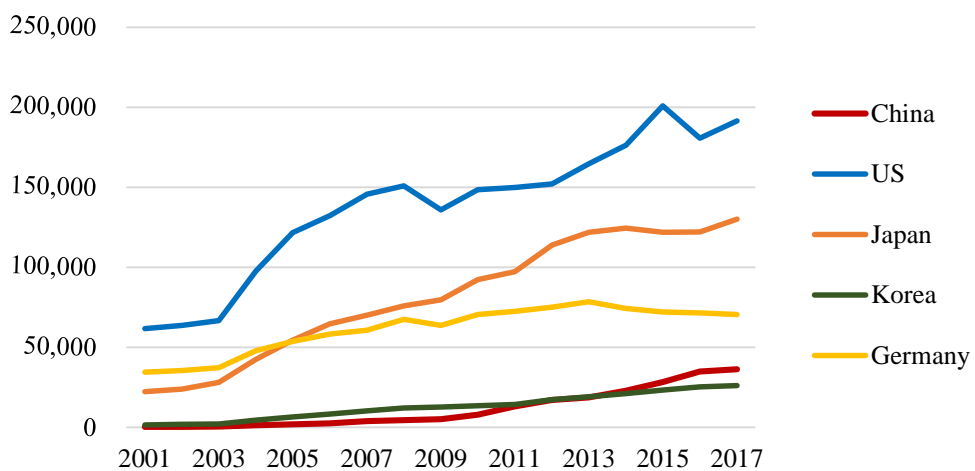
Source: WIPO Data Center

Figure 1 shows the number of patents submitted directly to the patent authorities in the U.S., China, EU and Japan on a yearly basis, except for the number of patent applications entered the national phase with PCT applications. While other economies are showing a stable trend, China has seen its patent applications grow at a very fast pace, with the number dominating other economies.

According to the location of the innovators who applied for the patents, 95.68 percent of the total number of patent applications directly applied to China as of 2017 were innovators residing in China, while 4.31 percent were from non-resident innovators in China. On the other hand, 42.36 percent of non-residential innovators in the U.S. were patent applications for non-residential innovators and 41.21 percent of non-residential innovators in the EU.

These figures show that China's patent applications dominate other economies in the world in terms of the volume of patent activity. Given that the size of China's domestic market is smaller than that of the U.S. and is not much different from Japan, however, one can expect that Chinese innovative players have an incentive to apply for patents other than applying for patents to transfer their innovation performance to the market. It is difficult to explain the exponential increase in patent activity in China alone by intensifying internal market competition in China.

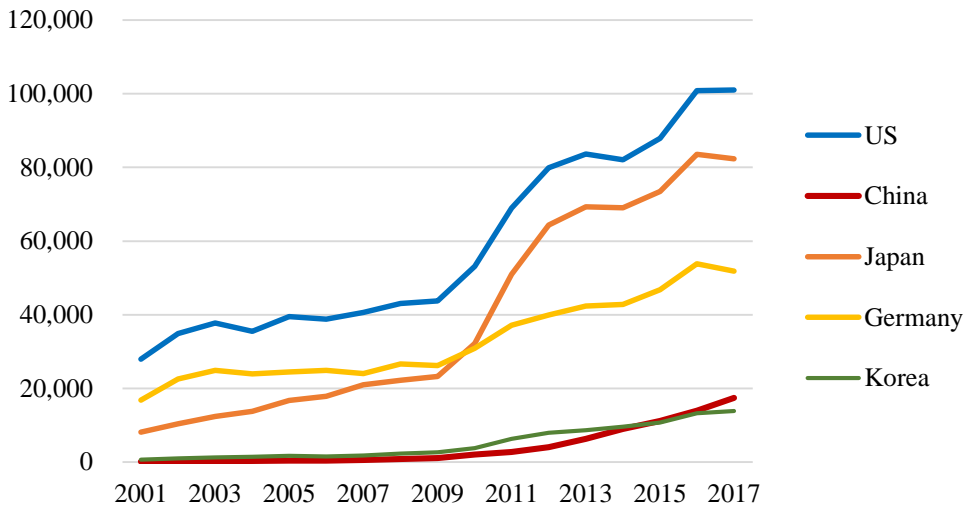
Figure 2: Number of patents aggregated in PCT national phase entries



Source: WIPO Data Center

Figure 2 shows the number of patents aggregated in the national phase-in of designated foreign countries by the location of the innovator after preliminary screening through the PCT procedure. Compared to 191,532 cases in the U.S. as of 2017, there are not many cases in which Chinese-based innovators applied for patents in foreign countries through PCT procedures. It is below Japan and Germany and somewhat more than Korea.

Figure 3: Number of patents grant for PCT national phase entries



Source: WIPO Data Center

This aspect is better illustrated by the classification by location of the innovator whose patent has been granted through the PCT procedure. As seen in Figure 3, there are not many PCT-approved patents that have been applied by Chinese innovators. As of 2017, the number stood at 17,390 compared to 100,979 in the U.S., falling short of one-fifth. So what's behind this patent miss-match phenomenon in China? As to the causes of this phenomenon, Santacreu and Zhu (2018) predict that Chinese innovators have a large incentive to obtain the domestic patent.

3 Increase in patent applications driven by local governments

As can be seen in Figure 1, domestic patent applications in China have increased steadily since the early 2000s and explosively increased after the 2009 global financial crisis as a turning point. Many existing studies have presented detailed explanations about this phenomenon.

First, a fact pointed out as the most important factor in existing studies is that increases in domestic R&D expenditures in China led R&D activities to patent production. Through an analysis, Motohashi (2008) indicates that that patent activities of higher educational institutions linked to the industry have begun to become active from the early 2000s, and Hu and Jefferson (2009) explain that patent applications increased thanks to many incentives given to R&D and patent applications and acquisitions by the Chinese government authorities, and innovator-oriented revisions of patent systems.

Through regression analyses using Chinese domestic patents as a dependent variable, Zhang (2010) explains that increases in activities through R&D expenditures are the primary cause of the increase in patent applications.

Indeed, the increases in R&D activities and patent applications in the early 2000s are related to the changes in the internal innovation system of China (Gu and Lundval, 2006). To join the WTO, the Chinese government authorities reformed the Chinese state-owned planned industrial system into a modern system. The existing system borrowed from the Soviet Union's planned economy system where factories and R&D units were established in a hierarchical form, and resources were allocated according to a budget allocation by industrial sector planned by the central authorities was reformed. The system transition of government-affiliated research institutes made from 1999 to 2001 is important. At that time, most of the 1200 and some more government-affiliated research institutes changed their systems. About 300 were incorporated into other institutions, such as corporations, about 600 were converted into profit-making corporations instead of public institutions, and some were incorporated into colleges. In addition, government subsidies were reduced, and R&D organizations were encouraged to continue R & D activities by winning projects by themselves in the markets. The essence of the reform is the change in the motivation structure for innovators from the system where R & D activities were conducted according to the instructions of the planned economy authorities and demand to a system where R&D activities are driven by market demand. In addition, R & D projects began to be given based on performance so that the motive for innovators to emphasize patent creation as their performance was strengthened.

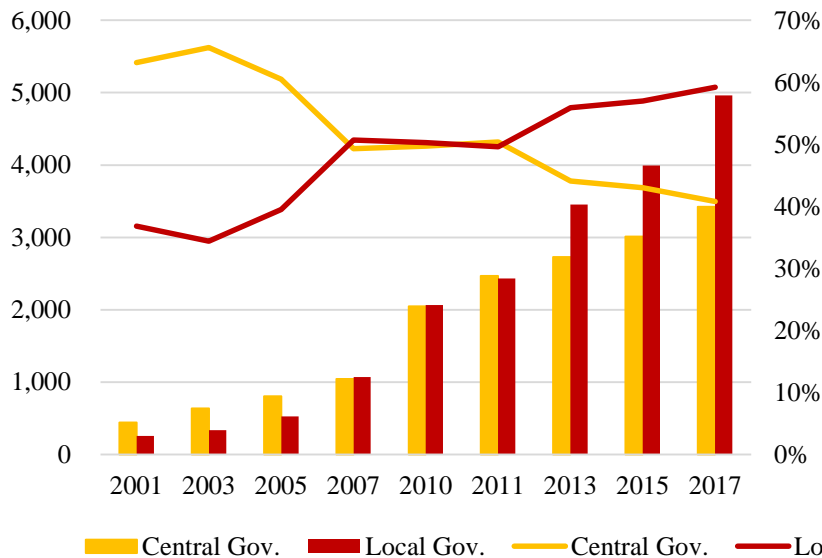
Table 2: Domestic R & D expenditures in China during the period of reform and opening

	1987	1990	1995	2000
Domestic R&D expenditures in China	6.74	12.54	34.87	89.57
The ratio of corporate expenditures (%)	29.3	n.a.	43.7	60.0
The ratio of independent R&D institutes' expenditures (%)	54.7	n.a.	42.1	28.8
The ratio of colleges' expenditures (%)	15.9	n.a.	12.1	8.6

Source: Gu and Lundval (2006, p.16)

This situation was intensified as another motivation structure was strengthened due to the active promotion of development into an innovative country by the Chinese government. After China joined the WTO, Chinese companies faced competition in the international market and technological gaps between Chinese companies and companies in other countries were revealed. To unravel this situation, the Chinese leadership started in October 2005 that it would promote the “The National Medium- and Long-term Scientific and Technological Development Plan 2006~2020” and completed a plan containing concrete action plans in February 2006 through consultation with more than 2,000 experts in various industrial, academic, and research fields. The plan emphasized ‘indigenous innovation’ (*Zizhu Chuangxin*). China made a policy to increase the capacity of domestic R&D institutes and firsthand support their scientific and technological activities, believing that only through this policy can Chinese domestic companies secure their own core technologies and gain sufficient technological capabilities. The central government, which secured stable tax revenues after the tax reform in 1994 and the entry to the WTO, selected fields for government procurement and support with R&D expenses and promoted support through the 11th Five-Year Plan (2006~2010) and the 12th Five-Year Plan (2011~2015).

Figure 4: Central and local government expenditures in science and technology spending



Source: Ministry of Science and Technology of PRC, <http://www.most.gov.cn/kjtj/>

As Chinese local governments actively participated in the Chinese central leadership's plan as such, R & D and patent activities explosively increased in China. Gu, Serger and Lundval (2016) analyze that the Chinese innovation system is evolving with a characteristic of increases in R&D expenditures centered on local governments. This phenomenon becomes clearer in reviewing Figure 4. Local governments' science and technology spending increased more rapidly than central governments' science and technology spending. Local governments' science and technology spending in 2017 was 20 times that in 2001. The proportion of local governments' science and technology spending became clearly higher than that of central governments' science and technology spending since 2006 and became even higher in Xi Jinping's regime since 2013.

Along with the increase in local governments' R&D expenditures, the patent activities of local innovators surged. Among studies that well illustrate the mechanism in which the effort to create patents centered on local governments affected the motivation structure for innovators is a study conducted by Li (2012). Li (2012) argues that the phenomenon of increases in patent applications in China cannot be fully explained without considering changes in the institutional patent activity encouragement systems of

Chinese local governments such as R&D subsidies and tax cuts. He argues that most decisively, the causes of the sudden increase in patent applications to the US Patent Office (USPTO) and the EU Patent Office (EPO) by Chinese innovators, and the expansion of regional imbalances in patent applications, can be explained only through the factor of local government's patent activity incentive systems. The Shanghai local government prepared and began to operate a fund to subsidize costs necessary to apply, register, and maintain patents for the first time in 1999 and the Beijing, Guangdong, Tianjin, Jiangsu, and Chongqing local governments raised funds and began to operate similar systems in 2000.

Table 3: Provincial governments' operation of patent subsidy systems aggregated by 2008

Year	Local government	Accumulated Number
1999	Shanghai	1
2000	Beijing, Tianjin, Guangdong, Jiangsu, Chongqing	6
2001	Zhejiang, Heilongjiang, Guangxi, Hainan, Sichuan, Shanxi	12
2002	Fujian, Jiangxi, Henan, Guizhou, Neimenggu, Xinjiang	18
2003	Shanxi, Anhui, Shandong, Yunnan, Tibet	23
2004	Jilin, Hunan	25
2005	Hebei, Qinghai	27
2006	Liaoning	28
2007	Ningxia	29

Source: Li (2012, p. 248)

Although the sizes of funds and the levels of subsidies operated by individual provincial-level local governments depended on the availability of finances of the local governments, local governments began to competitively raise and operate such funds. For example, Shanghai operated a fund of RMB one million at the beginning, while Chongqing operated a fund of about RMB200,000. These funds subsidized companies located or

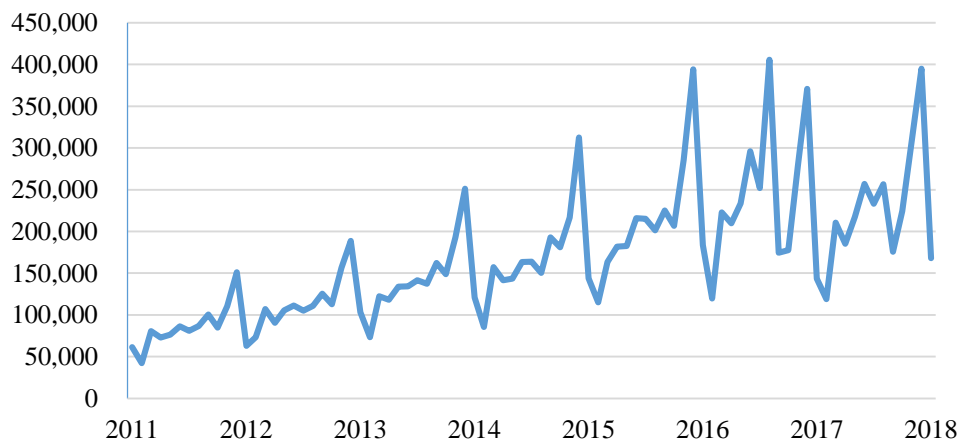
individuals residing in areas under the jurisdiction of the local governments without discriminating between companies and individuals. In addition, it is said that subsidies for overseas patent applications were commonly large. These subsidies were paid based on the number of cases regardless of technology areas. Therefore, the motives for the patent activities of innovators in China increased significantly. Once patent activities had begun, knowledge of patent applications and approval procedures was accumulated, and as this knowledge was diffused, and specialized, regional patent capacities were enhanced. According to Li (2012), the approval rate of overseas patent applications has increased since the changes in local governments' systems as such, and the quality of patents was improved.

There is a study, which indicated that there was political motivation mechanism for such local government-led patent activities based on the analysis. As examined earlier, local governments took the lead in increasing R&D expenditures and motivating patent activities to enhance the innovation capacity of innovators in areas under their jurisdiction. In the background of these efforts to improve the system was competition among local government leaders for political promotion. Lei, Sun and Wright (2014) analyze the motives as such thorough analysis of Chinese domestic patent application data from 1986 to 2007.

Fundamentally, it is said that political leaders in local Chinese governments have a tenure of three years and they have a motive to encourage patent activities because the innovation performance of areas under their jurisdiction in the tenure may be reflected on their individual evaluation indexes. Although no clear document on the evaluation criteria for Chinese political leaders has been secured, the foregoing can be confirmed through various pieces of anecdotal evidence such as public notices advertising that a yearly quota of patent applications was achieved earlier posted by some administrative units or disclosed documents delivering evaluation policies from some administrative units to cities under their jurisdiction for example. Lei, Sun and Wright (2014) indicate based on analysis that such pieces of news are mainly published in the online news sections of local governments and since they are usually good pieces of news, quotas and goals regarding patent applications implicitly existed in China.

Lei, Sun and Wright (2014) also suggest seasonal trends of patent applications as a basis of the analysis as such. The data from 1986 to 2007 after the enactment of the Chinese patent law in 1985 showed a phenomenon in which the number of patent applications in December was consistently larger than that in other months. This is attributed to the fact that the patent applications allocated to local governments in China are evaluated in January. Indeed, a document of Guangxi Zhuang Autonomous Region dated November 25, 2011, was delivering a policy to evaluate the situations of patent applications of cities under the jurisdiction of the regional government in January. Lei, Sun and Wright (2014) reported that for this reason, situations, where existing patents were divided into 'small' patent applications or patents, are quantitatively increased in the form of co-applicant patents by linking with patent inventors in other areas in order to fill the quotas and exceed their targets were observed from innovators in December. Although patents in December do show a tendency to be qualitatively low because the number of citations of patents in December is not smaller than that of patents in other months, the analysis indicates that more characteristic increases in the number of patents are observed in December for the above-written reason. Since the analysis by Lei, Sun and Wright (2014) was conducted with data until 2007, recent trends were analyzed, and the results were similar as can be seen in Figure 5.

Figure 5: Monthly numbers of applications for domestic patents of invention in China



Source: CNIPA Data Center

Patent applications showed a pattern of consistent increases in December and decreases in January. This pattern appeared identically over many recent years, except for August 2016. In 2016, since the number of patent applications in August was relatively large, the numbers of patent applications in other months, especially in January were small. Patent applications in 2018 and 2019 were not included in the analysis, considering the possibility of high ratios of patents not yet published after filing. Chinese patents can be published when one year and six months has passed after filing. The trend shows that patent applications are increasing and it can be regarded that the motivation mechanism for Chinese innovators has not yet been changed very much.

Local governments can inject funds into related local banks or state-owned enterprises with tax revenues secured through real estate development, etc. and the relevant local banks or state-owned enterprises became to have motives to allocate resources more intensively to those enterprises and industries that can play roles in the management of allocated goals of local governments such as the number of patent applications. Universities and research institutes also become to have motives for active development of patent activities to receive benefits from R&D project funds operated by local governments. Through this mechanism, local governments induce innovators in areas under their jurisdiction to strengthen their capacity for innovation through patent creation.

4. Amendment of Chinese patent law and patent activities of FIEs/Chinese firms

Based on the analysis, existing studies indicate that behind the phenomenon of increases in domestic patent applications in China are increases in the patent activities of the foreign-invested enterprise (FIE) following the increase in FDI and the patent activities of domestic firms in China intended to compete with the FIEs. Motohashi (2008) states that in the early 2000s, non-residents' patent applications by Japanese companies accounted for a large proportion of domestic patent applications in China. Hu and Jefferson (2009) explain that patent applications increased thanks to the revision of the patent system and that in relation to the foregoing, the patent activities of enterprises with foreign capitals, which have implemented FDI, account for a large portion. Zhang (2010) also indicates that the second revision of the

patent law made in 2000 and the patent activities of FIEs thanks to the inflow of FDI are the cause of the increase in patent applications in China.

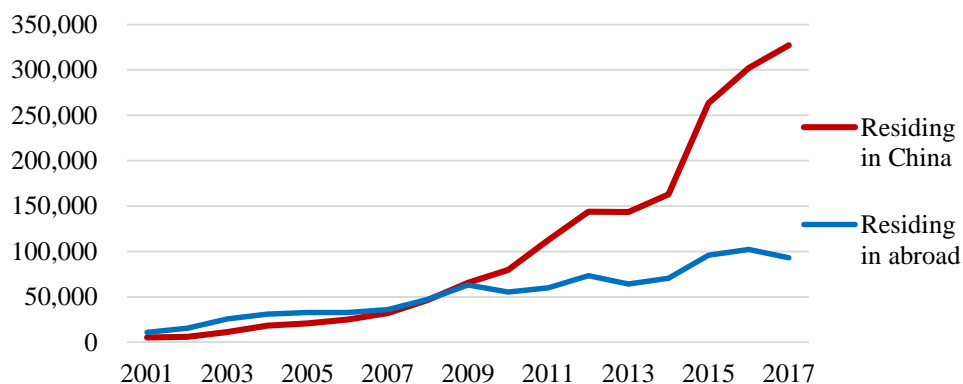
In particular, the second revision of the Chinese patent law made in 2000 is very important. Eun (2004) well outlined the meaning of the second revision of the Chinese patent law, indicating that before joining the WTO, China was requested to have an intellectual property system coincides with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) and enforced the revision of the Chinese patent law from July 2000. Importantly, the revision raised the level of protection of patents by stipulating not only the sale of patent-related products but also the act of offering of sales without the patent holder's permission as acts of infringing patents. In addition, the revision stipulated that compensation for patent infringement should be calculated by multiplying the comprehensive amount including not only the loss of profits of the patent holder but also the gains illegally obtained by the infringer and the royalties under the contract license. In addition, the revision enabled preliminary injunctions against potential acts of infringing patents by court order before the action against infringement of the patent by the patent holder. Furthermore, the revision restricts the compulsory licensing of dependent patents to a stricter situation than before. As the Chinese patent law promised to protect and enforce patents at the international level, it became easier for FIEs that implement FDIs in the Chinese market to exclusively possess technologies through the patents.

In addition, the patent law revised in 2000 simplified the procedure for patent applications by FIEs and Chinese firms located in foreign countries. When innovators located in foreign countries apply for Chinese patents, they were not required to submit documents or investigation reports obtained during patent examination in third countries. In addition, the provision that required Chinese innovators to get the permission of the relevant authorities when they for foreign patents was deleted. These measures lowered the threshold for patent applications so that innovators can more freely engage in patent activities and helped the Chinese innovation system evolve into a system where knowledge flows faster and more efficiently through open information.

Thanks to the background as such, Chinese patent applications by FIEs increased sharply from the early 2000s after China entered into the WTO. Through empirical analysis, Hu and Jefferson (2009) found that the patent activities of FIEs showed a tendency to significantly increase since 1999. Interestingly, in this analysis, the correlation between R&D activities and patent activities was not high in the case of FIEs while being very high in the case of Chinese firms. It can be judged that in the case of FIEs, innovation outcomes obtained in the countries where the head offices are located were introduced into China or the results of localization through application and development were utilized in patent activities in China. FIEs, that is, the China branches of multinational corporations played a role of applying and using head offices' patents in China.

Therefore, in the early days, the correlation between R&D and patent applications of FIEs was lower than that of Chinese firms that directly connected R&D activities to patent applications. As can be seen in Figure 6, among the patents approved in China from the early to the mid-2000s, the number of those that were applied by foreign innovators was larger than the number of those applied by Chinese innovators. In 2002, 5,868 patents were granted to applicants who reside in China and 15,389 patents, which are more than two times of the foregoing, were granted to applicants residing in abroad. For this reason, most research papers that analyzed innovation in China in the early 2000s evaluate that most of the important innovations in China were made by FIEs, and take notice of the fact that the ratio of applied research and development research in China was high.

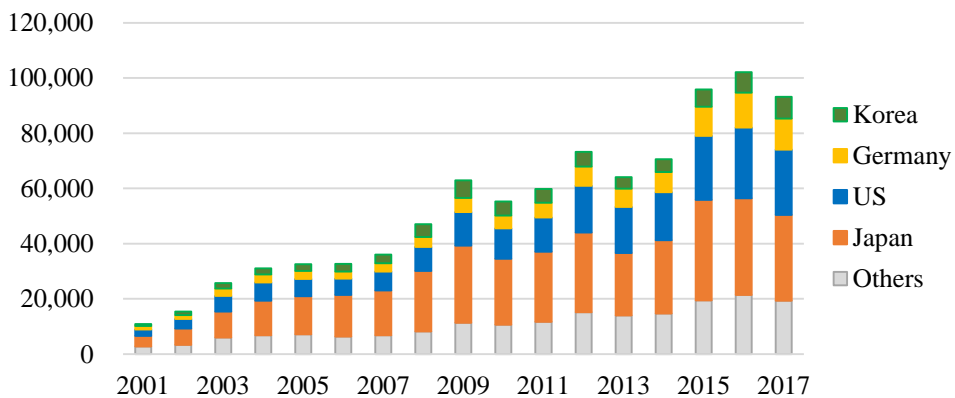
Figure 6: The number of patents approved in China divided by the patent applicants



Source: WIPO Data Center

Among FIEs, especially Japanese enterprises filed many patents. Japan was equipped with an advanced intellectual property right system early on and innovators accustomed to exclusive possession of technologies through patents have been developing in Japan (Motohashi, 2008). In the Chinese market, which was opened due to the entry into the WTO, too, the foregoing Japanese innovators began the effort to hold a dominant position in competition by preoccupying patents early on. As can be seen in Figure 7, even until recently, among applicants residing in foreign countries that filed patents in China, those located in Japan accounted for the largest part of patent activities. Innovators residing in Japan have occupied more than 30% of patents granted to applicants residing in foreign countries and occupied 46.69% in 2008 followed by innovators residing in the US and Germany. Innovators located in South Korea also received many patents in China utilize the patents in China.

Figure 7: Ratios of major countries in patents filed by innovators granted by China



Source: WIPO Data Center

In the early-mid 2000s, patent activities in China were mainly conducted by innovators located in abroad, especially by FIEs, but according to analysis in studies, such patent activities diffused innovation and promoted Chinese innovators' patent activities. According to an analysis by Hu and Jefferson (2009), patent applications tended to increase more in industries with higher ratios of FIEs. It means that Chinese innovators could not but actively conduct patent activities to compete with FIEs. In addition, technologies were diffused while FIEs were cooperating with Chinese companies to enter the Chinese market, and the outcomes appeared as patents.

The industrial fields where FIEs enter the Chinese market are those in which market demand grows rapidly in China and, naturally, patent activities are actively conducted in such fields. However, many studies still point out that such increases in Chinese patent activities did not imply the capacity building of Chinese innovators (Shao, 2011).

Recently, however, opinions that the capacity for innovation of Chinese innovator should be reevaluated have been increasing (Atkinson and Foote, 2019). As mentioned earlier, competition for innovation in the Chinese market has been intensified through the 2006 indigenous innovation strategy and the 2008 global financial crisis and the result appeared as increases in the patent activities of Chinese innovators as shown in Figure 6. As of 2001, the number of patents granted to innovators located in China and the number of patents granted to innovators located in foreign countries was 5,395 vs. 10,901. Therefore, the innovation capacity of overseas innovators was clearly superior, and this was the case with for the qualitative aspect too. However, in 2017, this trend reversed drastically, and the number of patents granted to innovators located in China was 326,970, which was more than three times the number of patents granted to innovators located foreign countries at 93,174. The strengthening of the innovation capacity of Chinese innovators appearing as patent activities are worth noticing.

In the background of this phenomenon was institutional support that helped domestic innovators secure the capacity for innovation. The third revision of the patent law in 2008 also a great effect. According to Eun (2012), whereas the primary purpose of the second revision of the patent law in 2000 was to protect the patent rights of FIEs, the primary aim of the third revision of the patent law in 2008 was to strengthen patent protection and the capacity for innovation of Chinese domestic innovators. An important fact in this regard is that the revision strengthened the novelty requirements so that overseas innovators release higher-level technologies in China first and forces that patents for inventions completed in China should be filed in China first to enhance the overall technological level of the Chinese market and strengthen the capacity for innovation of Chinese innovators. Instead, the patent law was revised to clarify the right to share patents and make a system that facilitates the transfer of patents thereby strengthening patent protection and enhancing the motives of innovators for patent activities.

Meanwhile, to strengthen the competitiveness of Chinese firms, systems to restrict the access of enterprises with foreign capital to the Chinese market access were also established. For instance, the Chinese government procurement law, which had been drafted since 2007, states that products ordered by the Chinese government with government procurement funds must include at least a certain percentage of ‘indigenous innovation’ products and that if not, the approval of the fund will be cancelled. That is, the law made purchases from domestic companies in China mandatory. In addition, the system that requires FIEs to disclose their technologies as a condition for them to access the Chinese market has been organized from this time. For instance, according to the bill for revision of the Chinese patent law, which was drafted in 2009, enterprises with foreign capital had to disclose the contents of technologies obligatorily for the technologies to become standard technologies of China. This system was driven more strongly in the IT industry. Only Chinese citizens or corporations can enter the markets of national security-related information infrastructure-related products and in the case of such products, technical information had to be disclosed in the process of China Compulsory Certification (Ernst, 2011). The enforcement of such a system has the effect of promoting the transfer and diffusion of foreign technologies into China. FIEs had to calculate the profits and risks of entering the Chinese market and technology disclosure.

Whereas the motives for patent activities of FIEs were daunted as their access to the Chinese market was restricted, the patent activities of Chinese innovators became more active as their capacity for innovation was strengthened. In particular, the strengthening of the capacity for innovation of Chinese firms was outstanding and the reasons can be illuminated from various angles. First, Chinese firms have expanded their cooperation with FIEs to cultivate their own technological capabilities. Most notably, Gao (2014) concretely describes the process through which Chinese firms secure their independent capacity for innovation through cooperation with FIEs. A state-owned company Datang signed an agreement with Siemens in 2001 and began joint development of TD-SCDMA technology, the third-generation mobile communications standard. Among FIEs, only Siemens was interested in TD-SCDMA and another team of China was developing WCDMA technology jointly with Ericsson.

However, since securing independent communication standard technologies can technology monopoly and high-price policies in the Chinese market of FIEs and reduce royalty expenditures, Datang concentrated on the technology in which FIEs were not much interested so that Chinese mobile communication firms organized a consortium and jointly developed technical standards. Through joint development, Siemens owned 21.6% and 21.2% of patents related to TDD and SCDMA technology in 2006, respectively, while Datang secured 12.2% and 15.2%, respectively. In this process, however, Datang acquired know-how in the application and acquisition of standard patents, and this capacity for innovation was exerted completely in the development of 4G and 5G communication technology standards thereafter. Huawei has also participated in the TDS-CDMA technology development network since 2003 and signed a contract with Siemens to carry out joint research. In this process, Huawei secured a lot of know-how. That is, technologies were transferred and diffused. Knowledge is created not in the simple process of citation of patents but in the process of in-depth joint development and as a result, innovators in late coming countries can obtain the know-how of developed countries. As the Chinese market expanded, the foregoing occurred in many industries. In industries such as high-speed railway and power generation facilities, Chinese companies have collaborated with FIEs to produce patents and secure the capacity for innovation capacity thereby rising to world-class levels.

Second, Chinese firms secured patent rights and technologies through active mergers and acquisitions of foreign companies. As the Western economy lost its growth engine during the time of the global financial crisis, China's share in the global economy has expanded dramatically. China has been able to secure a large number of foreign exchange reserves by maintaining solid growth even in the financial crisis through trade surpluses and managed such foreign exchange reserves strategically. Representatively, the Chinese government actively encouraged institutionally, companies to invest in foreign companies that would enable them to enhance their capacity for innovation, which is called 'going global' (Zǒu chūqù). 'going global' was mainly composed of strategic investments to secure resources as an axis, and there were many cases of mergers and acquisitions of overseas brands, but the ratio of investments to secure technologies was also high.

As a representative example, in 2010, Geely Automobile Holdings Limited of China got loans from the Bank of China and the Export-Import Bank of China to acquire Volvo, Sweden thereby upgrade its technological capabilities one level further. In 2015, when the enthusiasm for mergers and acquisitions was the highest, Sany Heavy Industries got loans from CITIC Bank to acquire Putzmeister in Germany. That is, it was a strategic step supported by the government. In 2017, a Chinese state-owned chemical company, ChemChina completed the acquisition of the Swiss seed company Syngenta to secure the ownership of seed and pesticide technologies. Syngenta is a company that has massive grain genetic information and plant variety protection rights (patent rights) in the world. Through mergers and acquisitions of enterprises, China is securing the time to advance innovation and building the capacity to produce new patents.

Table 4: Recent trend of overseas mergers and acquisitions of China

	2014	2015	2016	2017	2018
Overseas M&A(100 million dollars)	521	574	2,105	1,224	941
The ratio of overseas M&A FDI(%)	42.3	39.4	107.3	77.3	72.5

Source: China Specialist Forum <https://csf.kiep.go.kr/home/M000000000/index.do>

In this background, the situation where innovation in China had been led by FIEs was completely changed into a situation where innovation was led by Chinese domestic firms. As the capacity for R&D of enterprises that have been leading the world begins to be exerted in response to the demands of Chinese innovators, the capacity for innovation of Chinese innovators is being strengthened. The market share and competitiveness of Chinese innovators in individual industrial fields are strengthened.

5. Summary and Concluding Remark

Although it is difficult to demonstrate the direct correlation between patent activity and innovation capacity for several reasons, the following conclusions can be drawn up. First of all, the increase in patent applications in China is taking place faster than the growth in innovation capacity of Chinese innovators.

Local governments have a micro-motivation to encourage patent activities by innovators residing in their regions. Such patent activities are showing a trend of growing beyond the pace of China's growth in the international market. Secondly, the Chinese central government's institutions and policies have led to a greater incentive for domestic innovators to engage in patent activities than foreign-invested firms. Because of this, patents are increasing faster than Chinese firms' innovative competitiveness in foreign-invested firms in the Chinese market. Chinese innovators have collaborated with foreign-invested firms to produce knowledge through joint research and development, and more recently, mergers and acquisitions of foreign firms have been carried out aggressively to secure patents and knowledge in a short period of time.

In China, the improvement of innovation capabilities is unevenly achieved in certain industries and the diffusion effect of technology is limited. However, it is certainly observable that the increasing innovation capacity of Chinese firms in several industries is being enhanced. According to Atkinson and Foote (2019), China is on a level where it can create its own innovative performance and lead the global market beyond the steps of introducing foreign technologies through FDI and licensing and spreading them to other industries. For example, the three Chinese smartphone makers, Huawei, Xiaomi and Oppo, account for 32 percent of the global market, which was tallied from the fourth quarter of 2009 to the fourth quarter of 2018. BOE's Hefei LCD plant runs a highly automated plant, producing 10.5G world's largest standard LCD products. COMAC, a state-owned company in China, succeeded in a test flight of the 190-seat C919 and is beginning production. The plane will be delivered in 2021 and put on the official route. DJI is the world's largest producer of drones and has the largest share in the global market. Accordingly, it is expected that patent activities of Chinese innovators, especially firms, will become more active in the future. In particular, in the case of the ICT industry, both patent activities and innovation capacity of Chinese firms are rapidly increasing.

However, efforts by Chinese innovators, especially firms, to enhance their innovative capabilities are likely to face difficulties in the future. The U.S., Europe, Japan and other Western countries are nervous about the rise of China's innovators and are keeping China in check through various measures. In particular, the U.S. is blocking firms such as Huawei and DJI

from entering the U.S. market for their own security, and also restricts U.S. firms from cooperating with these firms. Germany has also lowered the criteria for government review when they receive overseas investment, prompting the government to impose restrictions on Chinese firms from increasing overseas mergers and acquisitions for their technology firms. In line with this global trend, Chinese innovators have become increasingly dependent on their own capabilities to continue their innovation. In particular, if the U.S.-China conflict is not resolved smoothly, China will face the problem of reducing direct foreign investment due to tariff barriers and securing foreign currency reserves to stabilize the yuan. Failure to solve this problem will damage the mechanism of capacity development of Chinese innovators discussed in this paper. In addition, if local governments fail to upgrade their industrial structure, they will face a vicious cycle of worsening financial difficulties and weakening innovative competitiveness.

Thus, it is necessary to take a close look at the Chinese central government's innovation strategy. The Chinese government avoids friction with foreign countries and innovates through internal institutional improvements. In relation to patent activities and innovation capabilities, the Chinese patent trading market system is being improved. This is aimed at enhancing the utilization of patents produced so that they can be linked to industrial innovation and contribute to enhancing national competitiveness. China is pushing for reform of the system by passing the fourth revision of the Patent Law, which began in earnest in 2014, at the National People's Congress in December 2018. It established and operated a court specializing in intellectual property rights, and established a system to better protect intellectual property rights by reorganizing the organization of the State Intellectual Property Bureau. It is also pushing for a punitive compensation system for infringement of intellectual property rights. The technology trading market is also continuing to expand its size. The Foreign Investment Law, which will go into effect in 2020, also emphasizes the protection of intellectual property in foreign-invested firms to encourage foreign-invested firms to introduce high-level technologies in the Chinese market.

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