Evaluating the Use of Patent Family for Understanding Globalized Industrial Innovation

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Abstract--**Industrial innovation based on intellectual property is a key process for creating competitive advantage in this globalized environment of knowledge economy. IP as a way of protecting innovation is becoming essential for both commercial and strategic objectives. Therefore, it is of importance to understand the global patent family portfolio which has been barely investigated systematically. The objective of this study is to measure degree of IP globalization based on different type of patent families defined in literatures. Also, it is observed that areas with extensive patent family coverages are consistent to industries or countries where IP is rigorously practiced for commercial or strategic purposes. Management implication are discussed in this paper to suggest a systematic way of how patent family can be analyzed to understand the globalized industrial innovation.**

I. INTRODUCTION

The progress of technology development, such as transportation and internet, which broke the boundaries between nations and formed the exchanges of cultural and economic. This phenomenon evolved effects of globalization. When it comes to globalization, we can talk from the Industrial Revolution of the 19th century. At the Industrial Revolution time, because of the breakthrough of technology, the producing process tended to be standardized in high quantity and low cost in the concept of economies of scale. Then, the invention of steamships decreased the cost of international trade and increased the frequency of international trade.

The concept of globalization has been more and more common all over the world. To be globalized countries or companies, people should increase their capacity and develop the competitive strategy. In the recent years, Northeast Asia has better performance on their economy growth rate, they are composed of developing countries and developed countries. They also have rich resource to component with each other. Their own brand such as LG and Samsung in South Korea, Alibaba and Xiaomi in China, Sony in Japan, HTC and Asus in Taiwan, these have become a large ecosystem. For other companies which are from other countries, like Google and Apple, the ecosystem from Northeast Asia has been strong competitors for them[1]. Besides advantages, there are also disadvantages in globalization environment. For example, the original local industries would be changed if they permit the import from other countries; the rise of information technology also causes some infringement problem. Thus, people start attaching importance to the knowledge protecting, that is why people use the intellectual property right to protect their knowledge asset from that time.

In the literature review, we found that globalization can be composed of several factors, such as innovation and competitive advantage. People can measure the degree of globalization from different aspect: economic, social, political, technological, and cultural[2]. They might be the price of the transaction[3, pp. 1800–1938], the economy environment and GDP of each country[4], or even the aspect of culture by the questionnaire[5].

"Globalization" is a conception word. It can be measured by different kinds of indicators. However, people usually focus on the dimension of economy. In the literature review, we found that the degree of innovation and the competitive advantage are also the factors which would affect the degree of globalization. For countries, the information can show the situation of them, it can help them to make the political strategy. For companies, they need more information to make management the resource internal, and the competitive strategy external.

If a local company performs well, it can also raise the competitive power of its home country and provide much more chance of the local employees. Recently, people pay attention to R&D, however, there are a lot of issue about the infringement. Therefore, the conception about how to protect the knowledge asset has become more and more important. Compare with the traditional way, people tend to use the IPR to prevent their R&D in these years. IPR is not only a way to prevent infringement, but also promote industrial innovation.

IPR has become a common and necessary way to protect the knowledge asset. On the other hand, patent can also be a tool to measure the claim and value of the R&D. Patent family is an important tool to analyze the information of patent, which includes the coverage range of the protection by the patent family[6]. Thus, in this research, we would discuss if the indicate of patent family can be used to measure the degree of global industrial innovation.

The contribution of this research is to analyze the industrial development of Northeast Asia in different way from others. In recent years, the growth of China and South Korea are not only a threat to Japan and Taiwan, but the entire Western markets have been affected. Thus, this research will focus the industries in Northeast Asia, and analyze by patent family for these ten years. Final, we will discuss if there are any evidence whether China and South Korea would lead the market in the future.

The paper is organized as follows: In Theoretical Background, we discuss innovation and competition in globalized environment, technology innovation and strategy,

and the globalized IP activities in literature review. In research method, we use the data base from PATSTAT, and select the number of patent families of each industry from 2004 to 2013. In result and discussion, we will discuss the patent family in both country level and technology sector level.

II. THEORETICAL BACKGROUND

A. Innovation and competition in globalized environment

In the globalized environment, innovation and competitive advantage are important for each company, industry, even the country. In 2008 and 2009, the global economic crisis, the venture has been one of concept at that time, the ability to innovate and create new products, services have been more important. How globalization, competitive, and innovation affect the structure of the environment is a big issue and has been discussed in a lot of literature. One of reason to innovation is that people produce the similar product in globalization environment, thus, a company should create their innovative ability to raise their competitive advantage, the most usual way is through the R&D density and patent number. We can say that innovation supports competition while making it more intense; on the other hand, competition is also a drive for innovation. Competition and innovation would affect each other on the same time [7]. To achieve the high competitive and innovation, the management strategy is a key process to be successful. Globalization may impact managerial decisions involving a firm's strategic scope[8]. For the company, they need some skill to improve their creating, producing, marketing and managing, also make the decision to maintain and develop their innovation skills. If a company manages effectivity, innovation would bring the competitive advantage for them[7]. When company find that imitation is difficult, they can create innovation with the local network because globalization and localization are growth at the same time[9]. Thus, government also make an important role to encourage local firm an environment of creating and innovation.

In recent year, the economic growth of Northeast Asia is higher than other advanced countries, it also plays a influential role around the world[1]. Taking the development of South Korea for example, their technologies started from imitating. When they catch up the the industrial progress, they start to be more innovative than others[10].

B. Technology innovation and strategy

There are some literatures show the evidence that technology will spur the globalization[11], in other words, technology is one of important tool to be competitive advantage and innovation power. Sometime people confuse about the meaning of technology, innovation and knowledge, therefore, people compared these three words together. The concept of technology, innovation, and knowledge are defined in deferent level. Innovation is like a platform for the technology, they describe technology is like leaves which are carried by the branches (Innovation). Knowledge is combine by technology and innovation [12]. In the innovate economy, technology is used to add the value of product, also develop new competitive strategy. The competitive power would lead the country to the higher level of the economic growth[13], [14]. Technology management is important for a company to acquire and apply. The position of technology moves from a differentiating competency to an operational capability. However, the capacity would be limitation easily, the company should innovate new technology asset continuously[15]. When being innovation, machinery and equipment acquisition and internal R&D activities may received much investment, but the result in the literature shows that meanwhile, software acquisition, training and industrial project and other technical preparations also play a high importance role on innovation though they do not received high investment[16]. Government try to stimulate the innovation activities by providing fund. In some emerging countries, they lacks of mature technologies and enough equipment, they would encourage the relationship between the cooperation of research department and companies[17].

C. The globalized IP activities

Some literatures have shown that the relationship between the IP and innovation. IP is not only protecting the innovation, but also improving the innovation process[18], [19],[20]. A particular company involved in the innovation process might be able to capture the bulk of the value by closing off the innovation and protecting it with intellectual property rights[21]. There is rich information from patent data, therefore, the relationship between innovation and patents would be more close[22],[23]. Patents can foster the disclosure of technology and the industrial development[24].

Patent family data can measure the technology stock of countries and inventive performance. Patent family can be defined into two level: micro level and macro level. In the macro level, patent family can eliminate double counting in international comparisons of patent statistics, and set an economic threshold in patent statistics, estimate filing flows across different patent offices; In the micro level, patent family can estimate value of patent rights, estimate patent value based on citations or litigation, and analyze applicant patent strategies. They also analyze the patent family of several countries in three definitions: non-domestic, transnational, and triadic. These number can show not only the extended family size, but also the importance of the patent office in local[25], [26].

The purpose of this study is to measure the degree of globalization and find if the patent family can measure the innovation degree of each country. We generalizing the types of patent family, and analyzing the patent family of several countries and compare their value in different definitions including the limitation of each one. With the method above, we want to prove whether there any correlation between patent family and innovation.

III. DATA AND METHOD

To analyze the patent family information of Northeast Asia countries and technical field, we select the database of EPO Worldwide Patent Statistical Database (PATSTAT). We analyzed the data from the information in PATSTAT which not only has sufficiently patent information, it can also be used to statistic and built the customizing table[20]. PATSTAT is consisted with several tables which were classified into a different kind of application, for example, people can gather the information related to the classification by TLS209_APPLN_IPC, TLS222_APLLN_JP_CLASS, and TLS224_APPLN_CPC; or the information related to the patent families by TLS218_DOCDB_FAM and TLS219_DOCDB_FAM[25].

From the literature, it has mentioned about that patent family can be a useful indicator to measure a lot of phenomena. There are many different kinds of patent family in the literature, thus, we generalize those definitions into table1, and compare each one of them into limitation and applicability. We categorize these definitions into classification and sub-classification in table 1 and table 2. Classification means that the category's method of patent family counting. For example, there are three main kinds of patent family: extended, simple, and single-priority family. In the extended patent family, if you have any one priority in the document is the same with the priority in other documents, then the former document will be categorized into the same patent family with the later one. In the simple family, the priorities of each document would be the same. For the third one, single-priority family, it also called single first filling forming family. If the subsequent document's first priority patent is the same as former patent document, then they will be grouped into the same single priority family. Table 2 shows the sub-classification of INPADOC and DOCDB patent family. Transactional patent family can evaluate the commercial value of each patent family. Triadic patent family can measure the importance of patent which fills in three patent office. Geographic patent family can represent the importance of the local patent office. The higher the rate of geographic patent family is, the more importance the local patent office is.

To count the patent family information, we built the patent family table to count the INPADOC patent family and DOCDB patent family from PATSTAT, however, the limitation of single-priority family, we will not adopt this kind of patent family in this paper. Based on the applicability of INPADOC extended family and DOCDB patent family, we decided to use the definition of INPADOC to measure the patent family of each country and industry. In order to demonstrate the relationship between patent family and the degree of globalization, we take the countries in Northeast Asia for the case in this paper because of the quick development in recent years. Thus, we set these ten years to be the measurement period to avoid the accumulated patent counts before, and the countries in The Northeast are Chinese, South Korea, Japan, and Taiwan. Table 1 is the total patent number of these four countries between 2004 to 2013. China own the highest patent number of these four countries. However, the patent number may be affected by the size of nations, therefore, figure 2 shows the growth rate every year. From 2004 to 2007, the patent number of Taiwan was increasing continuously, then, the number started to decrease from 2007 rapidly. The changing of patent number in Japan are less than 0.041 before 2011, there are extraordinary decreasing from then. At the same time, Taiwan starts to increase the patent number. China maintained the growth rate between 0.2 and 0.4 every year from 2007. China was the only countries which didn't have negative growth rate of these four countries. The phenomenon shows that China has better performance in Northeast Asia these ten years, conversely, the growth rate of South Korea, Japan, and Taiwan were down to 0.6 to 0.8.

TABLE 1. THE CLASSIFICATION OF PATENT

Classification	Database	Definition	Limitation	Applicability
INPADOC extended family	EPO worldwide legal status database	The patent documents have any same priority in the documents with other patents, then they can be the same family.	Compare with the simple family, extended family can not protect the same information from the first filing to last filing patent.	It can be collected and organizes quickly with extended family.
DOCDB Simple family	EPO's master documentation database with worldwide coverage	All documents having exactly the same priority or combination of priorities belong to one patent family.	When collecting the information of simple family, it would consume time when inputs a single patent number for individual.	It provides the EPO with bibliographic and legal status data on a regular basis.
EPO-PRI single-priority family	EPO database	The patent documents have the same first filling priority.	It would be counted twice, for example, if there are two first filing, then the subsequent filing would be belonging to these two families.	It is regularly used in patent filings forecasting exercises.
WIPO single-priority family	WIPO	WIPO uses the same way to build the family of them.		

TABLE 2. THE SUB-CLASSIFICATION OF PATENT FAMILY

Classification	Sub-classification	Definition
INPADOC extended family	No-domestic	The members of family are fliting in other countries.
	Transactional	The family includes in at least one PCT or one EPO.
	Triadic	The family having at least one USPTO grant, one EPO application and one JPO application as family members
DOCDB simple family	DOCDB family	The counts of DOCDB family size.
	Geographic family	The family counts the patents which are granted in the local patent office.

TABLE 3. THE TOTAL PATENT NUMBER OF FOUR COUNTRIES IN NORTHEAST ASIA.

From 2004 to 2013

	CN	*JP*	*KR*	*TW*
Total Patent Number	23742890	14652445	6502231	2257503

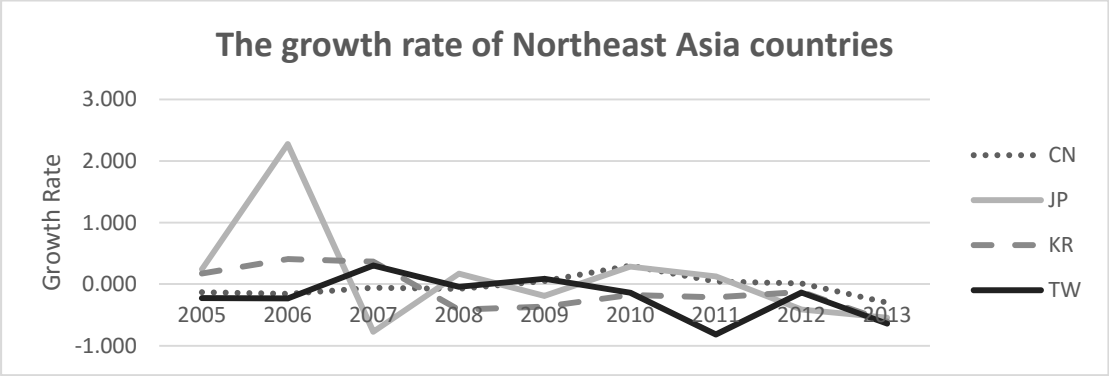

Figure 1. The growth rate of Northeast Asia countries

IV. RESULT AND DISCUSSION

According to the definitions in table 1, Figure 2 and Figure 3 show the patent family counts per patent of each country from 2004 to 2013. To avoid the patent family number would be affected by the total patent number, we count the patent family which divided by total patent number. We measure the correlation in table 5, there is no significant correlation between patent family and patent number. Table 4 is the average patent family counts per patent. Compare to the trend of patent number in figure 1, the INPADOC patent family performance of China is different from the patent number. From 2004 to 2012, the rate patent family of Japan are around 0.25, it maintained a stability until 2013, it dropped to 0.09. The rate of South Korea are ups and downs these ten years, in 2013, it was also down to 0.06. In 2007, the rate of Taiwan got the highest rate to 0.60, but it started to decrease since then. The situation of DOCDB patent family has similar performance of these countries in recent ten years. However, we found the correlation number of INPADOC and DOCDB is closed in table 4. Thus, we can see the trend of INPADOC and DOCDB patent family is similar in table 6. Compare with the literature of patent family[26], the result is the same which mentioned the different between this two patent family is that INPADOC family includes published applications and unpublished applications that have been cited or claimed. For the phenomenon that the rate of patent family in each country were lower than before, we statistic five technology sectors of each country by INPADOC patent family. We try to analyze if there are any evidence shows that the phenomenon below is caused by certain technology sector. In the literature review, it has mentioned that the relationship between technology and globalization. If it does, we can evaluate the trend of each sectors in each country of Northeast Asia. Therefore, figure 5 shows the five technology sectors of each country. Japan has extraordinary patent family counts in these five sectors. Compare with the number of China in table 3, which has larger patent number than Japan, but their patent family number is even less than South Korea. It may means that the value and the degree of globalization is lower than Japan and South Korea. Table 6 is the growth rate of technology sectors in each country. Figure 6, 7, 8, 9, 10 are the growth rate of each technology sector from table 6. Though we said the degree of globalization of China is lower than other countries in Northeast Asia, but their patent family growth rate stayed nearby with others from 2008. However, the situation of Taiwan was not ideal. It performed well from 2006 to 2008, then, it started to decrease every year in each sector. It would be a sense of crisis for Taiwan in the future.

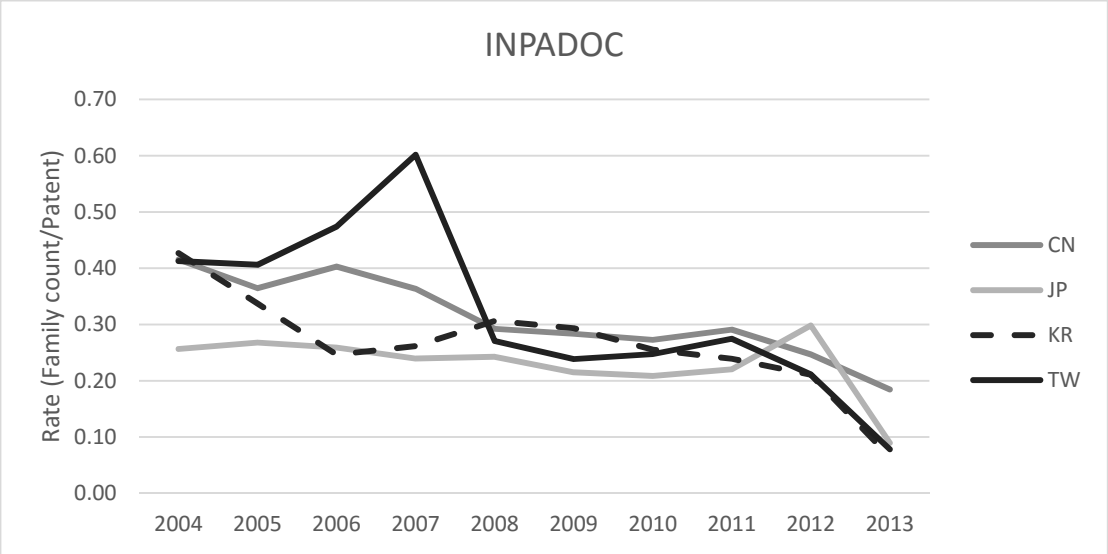

Figure 2. The rate of INPADOC patent family

TABLE 4. THE AVERAGE RATE OF PATENT FAMILY COUNTS PER PATENT

	CN	*JP*	*KR*	*TW*
INPADOC	0.31	0.23	0.26	0.32
DOCDB	0.30	0.19	0.23	0.32

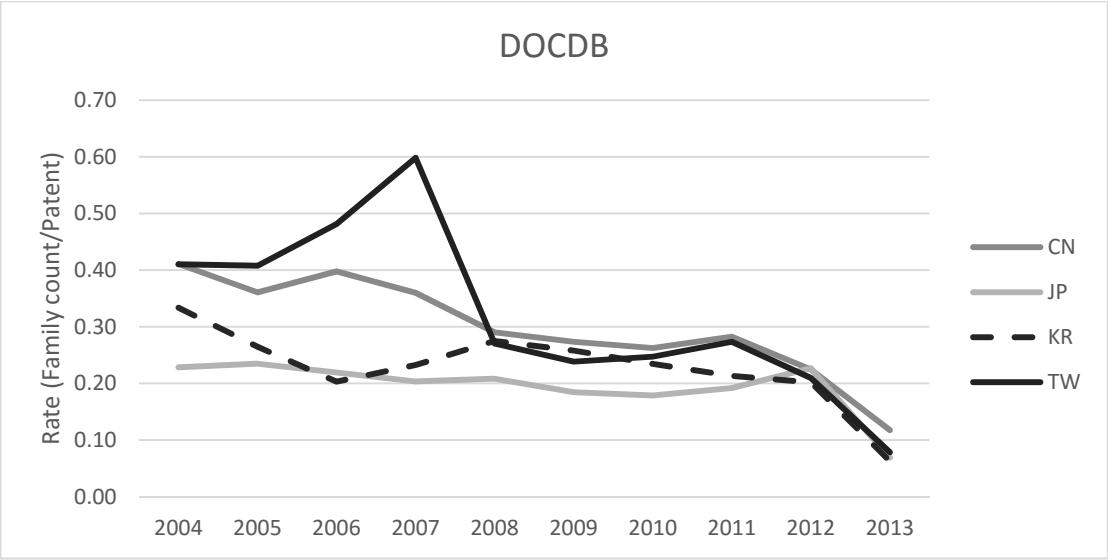

Figure 3. The rate of DOCDB patent family

TABLE 5. THE CORRELATION OF PATENT NUMBER AND PATENT FAMILY IN TWO DEFINITIONS.

	CN	*JP*	*KR*	*TW*
INPADOC	-0.90785	0.37883	-0.71106	-0.94077
DOCDB	-0.93712	0.54368	-0.605404	-0.94291

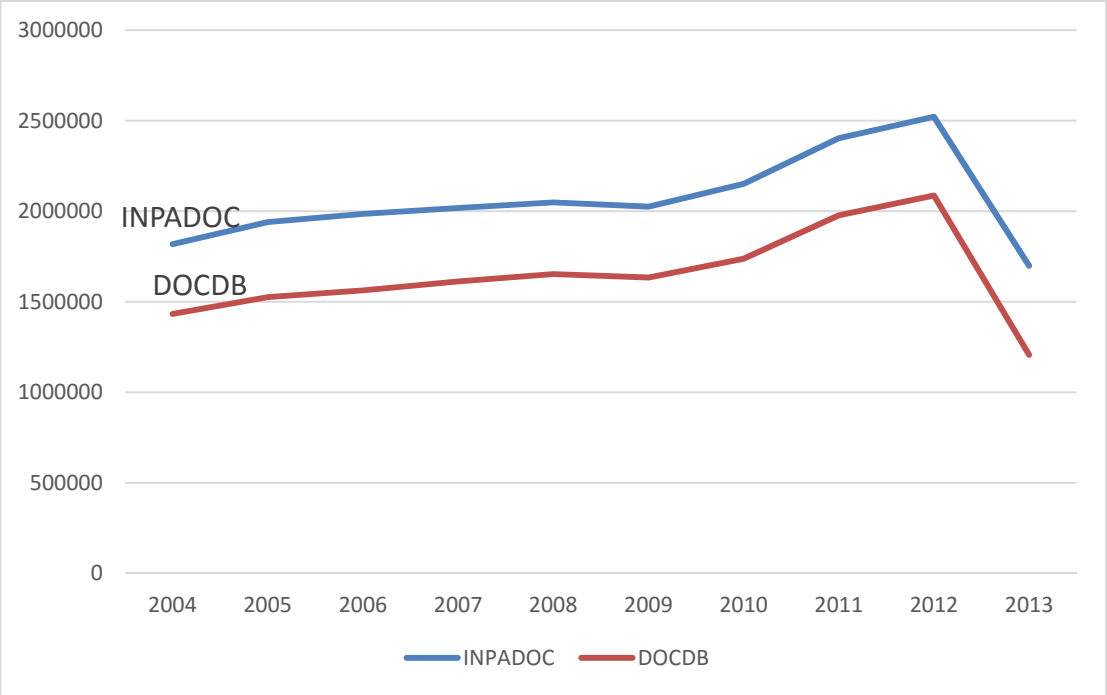

Figure 4. The total number of INPADOC and DOCDB patent family.

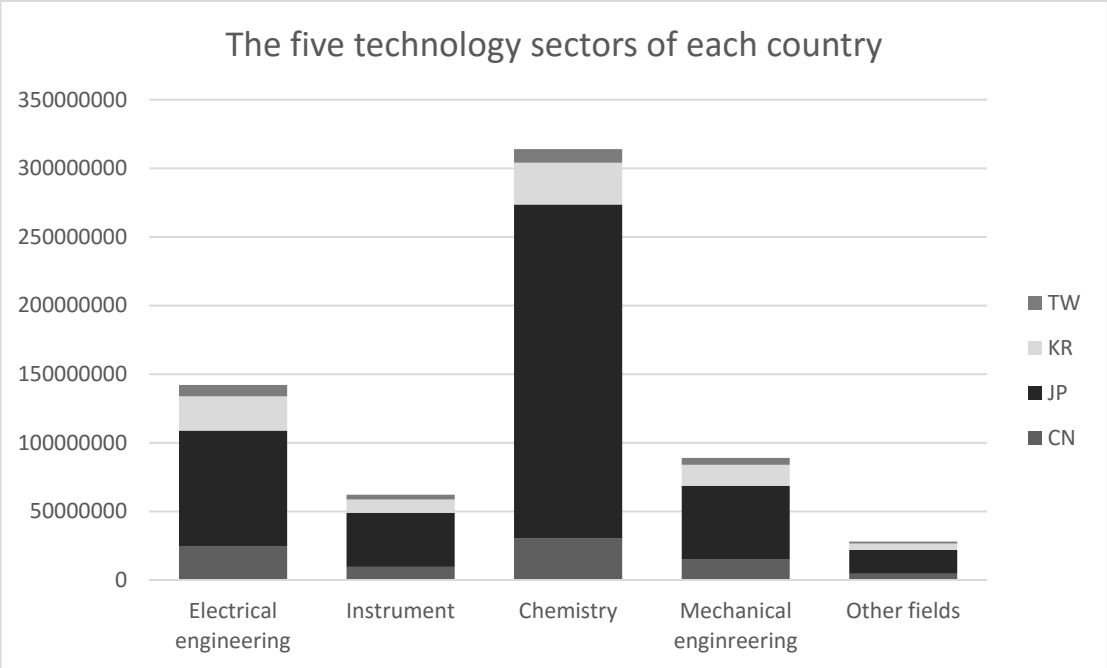

Figure 5. The five technology sectors of each country.

TABLE 6. THE GROWTH RATE OF TECHNOLOGY SECTORS IN EACH COUNTRY.

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CN	Electrical engineering		-0.338	-0.094	-0.176	-0.250	-0.009	0.024	0.102	-0.143	-0.443
	Instrument		-0.273	-0.142	-0.223	-0.170	0.024	0.043	0.130	-0.138	-0.465
	Chemistry		-0.214	-0.215	-0.257	-0.043	0.027	0.034	0.061	-0.204	-0.464
	Mechanical enginreering		-0.110	-0.260	-0.086	0.052	-0.007	0.145	0.146	-0.065	-0.318
	Other fields		-0.130	-0.154	-0.057	-0.074	0.052	0.302	0.045	0.015	-0.298
JP	Electrical engineering		-0.284	0.376	-0.231	-0.089	0.034	-0.012	0.097	-0.370	-0.463
	Instrument		-0.085	0.214	-0.333	-0.093	0.067	-0.039	-0.090	-0.268	-0.495
	Chemistry		0.971	-0.231	-0.367	0.425	-0.258	-0.302	-0.171	-0.223	-0.186
	Mechanical enginreering		0.008	1.077	-0.618	0.059	0.012	0.090	0.041	-0.376	-0.543
	Other fields		0.244	2.277	-0.771	0.173	-0.188	0.287	0.129	-0.409	-0.541
KR	Electrical engineering		-0.338	-0.094	-0.176	-0.250	-0.009	0.024	0.102	-0.143	-0.443
	Instrument		-0.273	-0.142	-0.223	-0.170	0.024	0.043	0.130	-0.138	-0.465
	Chemistry		-0.214	-0.215	-0.257	-0.043	0.027	0.034	0.061	-0.204	-0.464
	Mechanical enginreering		-0.110	-0.260	-0.086	0.052	-0.007	0.145	0.146	-0.065	-0.318
	Other fields		-0.130	-0.154	-0.057	-0.074	0.052	0.302	0.045	0.015	-0.298
TW	Electrical engineering		-0.403	-0.412	0.831	-0.215	-0.161	-0.131	-0.434	-0.227	-0.646
	Instrument		-0.286	-0.495	0.795	-0.202	0.018	-0.191	-0.508	-0.304	-0.636
	Chemistry		-0.348	-0.281	0.577	-0.070	0.066	-0.176	-0.404	-0.352	-0.703
	Mechanical enginreering		-0.269	-0.304	0.509	-0.122	0.049	-0.161	-0.765	-0.147	-0.665
	Other fields		-0.226	-0.231	0.304	-0.042	0.089	-0.138	-0.816	-0.134	-0.639

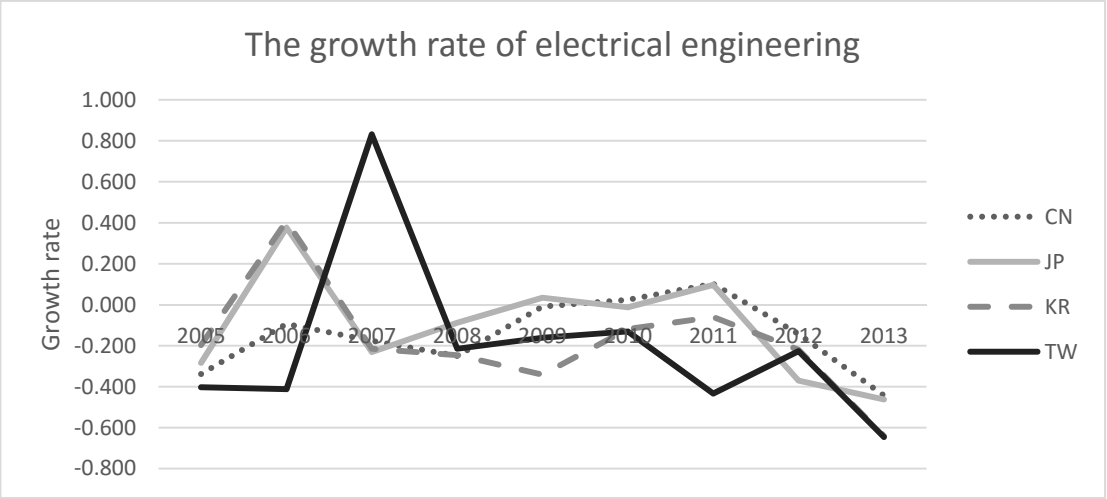

Figure 6. The growth rate of electrical engineering

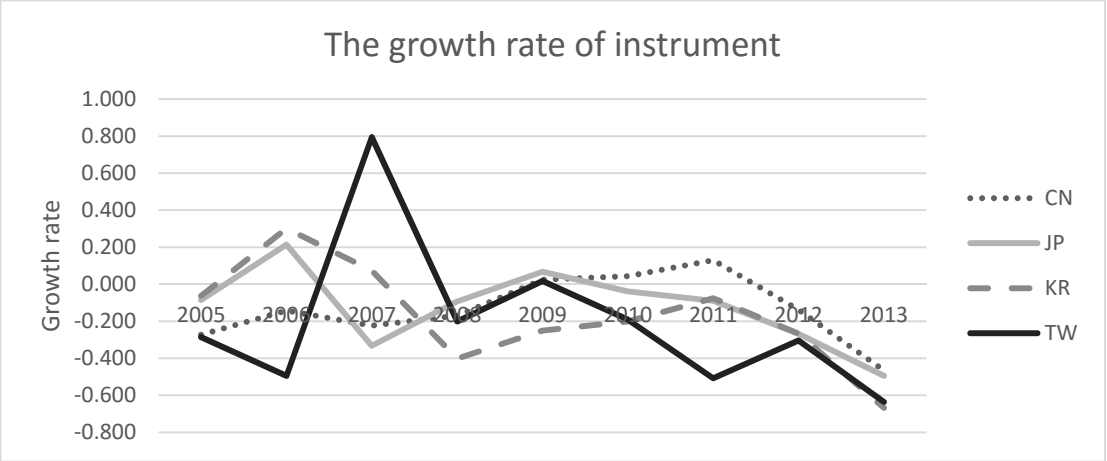

Figure 7. The growth rate of instrument

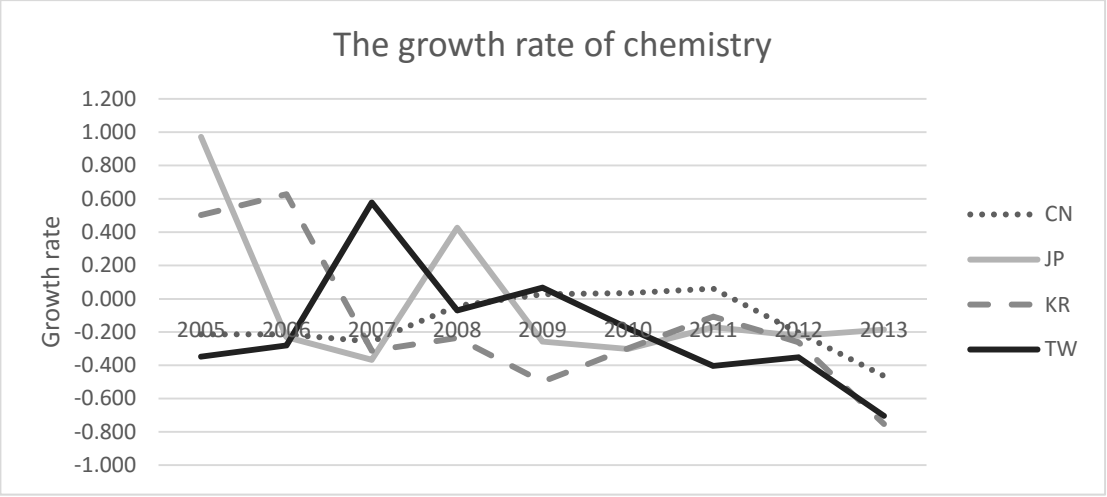

Figure 8. The growth rate of chemistry

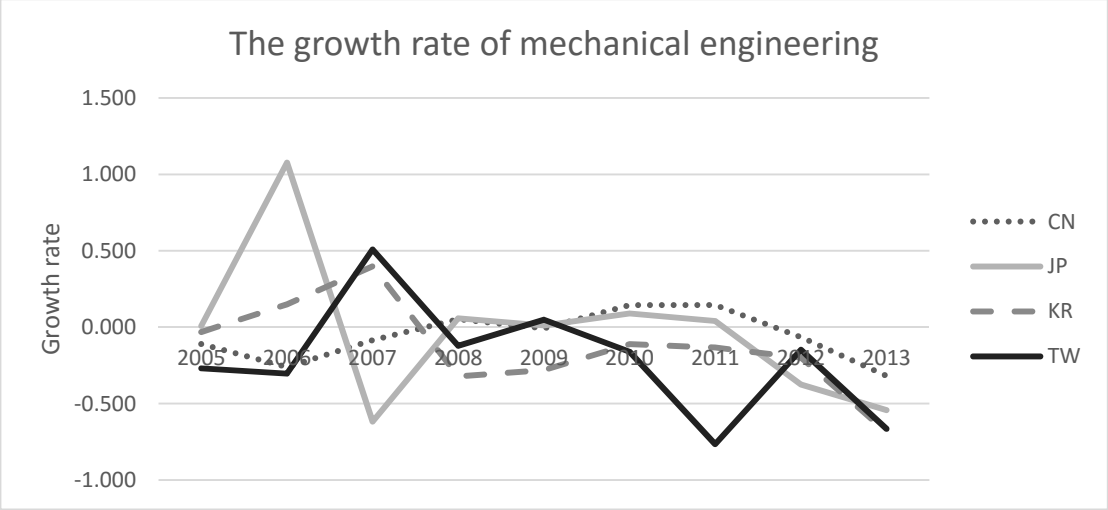

Figure 9. The growth rate of mechanical engineering

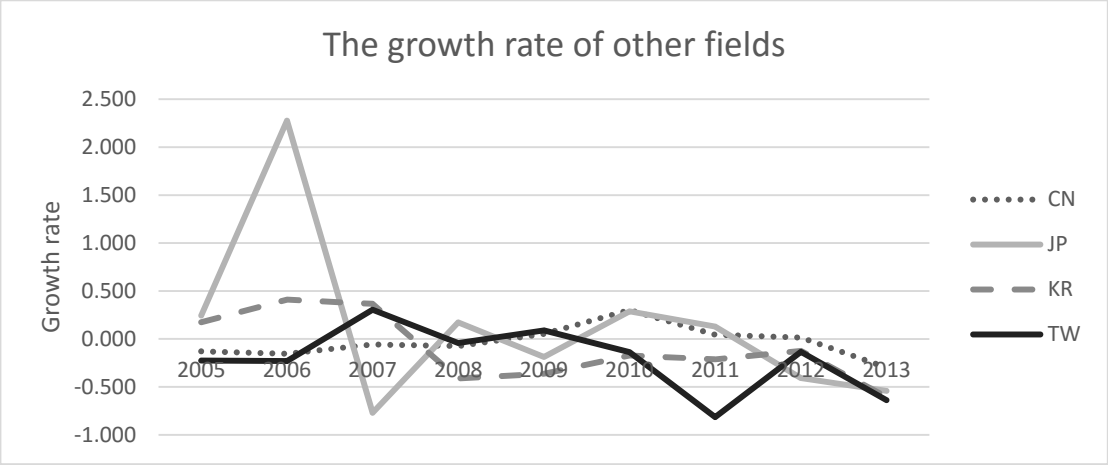

Figure 10. The growth rate of other fields

V. CONCLUSION

According to the definition of development degree by IMF (International Monetary Fund), we can also separate two types of countries. China is belonging to the developing country; Japan, South Korea, and Taiwan are belonging to the developed countries. We analyzed the performance of each country in country and technology sectors levels. We found that the total patent number may not represent the degree of globalization, but the growth rate of patent family in technology sectors shows that China's efforts in the past few years. Japan and Korea maintained stably performance in recent ten years. However, the performance of Taiwan is worried because of its regression after 2008. For Japan, the high growth rate may be related to the patent policy: Pilot patent prosecution highway. They shared search results with the intellectual property offices with USPTO. This strategy plan can leverage fast-track patent examination procedures already available in both offices to allow applicants in both countries to obtain corresponding patents faster and more efficiently.

The contribution of this research is to provide the situation of the five technology sectors of the Northeast of Asia. The limitation of this research is that we can only show the function of method of patent family. There are still lack of enough evidence to demonstrate the degree of globalization relationship of patent family. We did not consider the application location and the flows of the patent families in the research. Therefore, we will keep on researching the data method on patent family, such as triadic and transaction patent family which has much commercial value of each one. For the further research, we can combine the analysis of the difference inventors and applications of countries and discuss the relationship with the global innovation activities.

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