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Landscape of standard essential patents: The case of East Asian countries

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Abstract: Technical standards in the mobile communications industry have been developed from national to regional and from regional to global. In the current era, global standards in the industry have enabled the formation of a single global market. However, because standard essential patents (SEPs) are territorial given the nature of the patent system, they can function as an opportunity or a threat depending on whether or not they are protected in countries of interest. This paper investigates how W-CDMA and LTE SEPs owned by East Asian countries are globally distributed. From the analysis, the current study discovers East Asian SEP owners' strategies, future opportunities, and threats in their international businesses.

Keywords: East Asia, Essential Patent, Standard

JEL classification: L19, O30, O53

1. Introduction

In 2014, standard essential patents (SEPs) were re-recognized as a powerful tool for a manufacturer from China to use in order to operate a business built on relevant standards. SEPs are patents that contain essential technologies to run relevant standards. In 2014, Xiaomi, a smartphone manufacturer from China, infringed on SEPs owned by Ericsson. The result was a nightmare for Xiaomi. The Delhi High Court ordered the company to halt the sale, advertising, manufacture, and importing of its phones in India. This event indicated that international trade can be affected by SEPs even if the target standards are aimed at global markets.

Inspired by Xiaomi's case, this paper aims to investigate the geographical distribution of SEPs and to understand them from the East Asia perspective. First, understanding the geographical distribution of SEPs helps reveal trade-related opportunities and risks. Because SEPs are territorial, their owners can have exclusive rights only in the countries in which the SEPs are filed. In other words, this study does not analyze who owns "how many" SEPs even though such an analysis is meaningful in some sense. Emphasizing the fact that any single SEP can stop an entire standard system, this study focuses on who protects "where." In addition, because a patent filing represents a tradeoff between dominance and cost, this study assists in understanding the markets considered important by each SEP owner and those considered an opportunity or a risk given SEPs' geographical distribution. Second, the analysis is done from East Asia's perspective. The information and communication technology (ICT) industry, one of the most important in East Asia, is a typical industry for which standards play a pivotal role in its growth. Understanding the degree to which East Asian firms control standards will assist in determining their future business agendas in the ICT industry.

The contribution of this paper is twofold. First, SEPs' geography will assist in understanding the opportunities for and barriers to international trade created by such information. SEPs have attracted significant attention from scholars. However, recent studies regarding SEPs discussed their features, their appearance in standardization processes, their licensing, and other information. To the best of our knowledge, this approach is the first in attempting to understand SEPs as a barrier to/opportunity for international trade. Second, this study provides implications for East Asian countries. The ICT industry is very important for

East Asian countries because it has been a major contributor to their successful economic growth (Freeman, 1987; Kim, 1997; Amsden & Chu, 2003). Accordingly, this study is conducted in the context of East Asian countries and is expected to assist in revealing regional trends and perceptions. Analyzing SEPs is a practical approach because SEP-relevant issues are very important in the ICT industry, in which technological standards largely decide the success and failure of one's business and, ultimately, the way forward (Shapiro & Varian, 1999).

The remainder of this paper is organized as follows. In the next section, the relevant literature is reviewed. Then, the research data collection process is explained. The fourth and fifth sections present the findings and a discussion, respectively. The last section summarizes the findings and discussion, and provides suggestions for future research.

2. Literature review

2.1 Evolution of mobile communications standards—from national to regional and from regional to global

ICT has achieved the most dramatic technological progress in the past few decades. Its innovations have affected economic growth in various industries, none more than the mobile communications industry, which has evolved together with technical standards (Adachi, 2001; Dahlman et al., 2008).

The first-generation (1G) mobile communications systems were implemented in the 1980s. For example, the Advanced Mobile Phone System (AMPS) in the United States, Nordic Mobile Telephone (NMT) in Nordic countries, the Total Access Communication System (TACS) in the United Kingdom, and the Nippon Telegraph & Telephone System (NTT) in Japan were developed to provide mobile communication services. Because the services were aimed at the domestic market, 1G standards were national standards.

The 1990s saw the advent of 2G mobile communications standards: Global System for Mobile Communications (GSM) in Europe, Interim Standard 54 (IS-54) and IS-95—better known as the Code Division Multiple Access (CDMA) standard—in the United States, and Personal Digital Cellular (PDC) in Japan. Related to this generation, a significant step was taken in Europe in addition to increased throughput. To integrate European countries as a

single market, GSM was developed as a regional standard in Europe. The original goals of developing GSM were to achieve significant economies of scale in equipment supply and to provide roaming services (Shurmer & Lea, 1995; Gandal et al., 2003). Accordingly, GSM standardization efforts were made by firms in European countries.[1] In this sense, 2G standards were regional standards.

Demand for higher throughput always exists in the mobile communications industry. However, since the 1990s, demand for a global standard in the mobile communications industry had increased as an increasing number of people started to travel around the world and sought roaming services. As a result, global partnerships were created to develop 3G mobile communications standards that avoided restrictions to specific regions. However, multiple global standards were developed by different partnerships. For example, the Wideband-CDMA (W-CDMA) standard, officially a part of the Universal Mobile Telecommunications System (UMTS), was developed in 3GPP and the CDMA 2000 standard was developed in 3GPP2.[2] It is not difficult to imagine that standard wars occurred globally in the mobile communications industry.

The trend to set a global standard has continued for the 4G and 5G standards in the mobile communications industry.

2.2 Standard essential patents (SEPs)

Even if standards in the mobile communications industry are completed through global collaboration, another issue is deploying these standards into markets. Once a standard is realized, patents that protect the technologies to operate the standard become SEPs. Thus, deploying a standard is essentially accompanied by using relevant SEPs. SEP owners have merits, such as receiving revenue income from other implementers of SEP-comprised standards, bargaining cross licenses with both SEPs and non-SEPs, and so on. Because SEPs

[1] To be specific, Motorola also participated in the GSM standardization. Motorola's participation was special because it conducted extensive R&D activities in several European countries and had a significant number of SEPs for GSM (Iversen 1999; Bekkers et al., 2002).

[2] To be certain, 3GPP and 3GPP2 were competitors for the 3G and 4G standards.

are profitable assets, numerous companies attempt to obtain them by reflecting their own patents into a standard and by purchasing SEPs from others.

Obtaining SEPs in the standardization process, i.e., reflecting patent-protected technologies into a standard, is not easy. Standardization is for discussing and testing technologies to enable the valuable ones that provide better performance to contribute to the standard (Rysman & Simcoe, 2008). However, because many companies have different ideas in their technologies, standardization also allows for negotiations with other participants with different interests to harmonize different technologies. Because decisions should be made with the consensus of participants in the standardization process, standardization accompanies numerous interactions between participants (Leiponen, 2008; Bekkers et al., 2011; Kang & Bekkers, 2015; Kang & Motohashi, 2015). As an increasing number participate in the standardization, the process to reach consensus becomes more difficult.

Benefits exist to owning SEPs. First, SEP owners can receive a reward from standard implementers. Given the nature of SEPs, whoever implements the standard must have a license agreement with SEP owners. The reward can be either monetary or non-monetary rewards or both. The monetary reward includes a licensing fee and a purchase. The non-monetary reward can be a cross-license with a licensee's assets. Second, SEP owners can implement business strategies using their own SEPs. Owners can choose licensees and control licensing conditions. However, restrictions exist that are attributable to the IPR policies of standard setting organizations (SSOs), and such behaviors of owners are regarded as anti-competitive (Farrell et al., 2007; Lemley & Shapiro, 2007). If not, owners can simply keep SEPs as an asset that can be easily turned into cash.

2.3 International patent protection and international trade

The patent system is territorial. Accordingly, patent system protection levels are different between patent authorities, and these differences influence international trade. When a firm decides where to export their products and services, it must take into account the patent system of importing countries as a condition. If a country's patent system is weak and practiced poorly, no exporter will export its products and services to that country knowing that the chances are high that they will be imitated.

In contrast, if the patent system is strong and practiced well, an exporter would not simply increase its export to countries. Two countervailing effects occur when a patent authority sets a strong patent system (Maskus & Penubari, 1995; Smith, 2001). One effect is the market expansion effect, in which an exporter increases its exports to markets with a strong and well-practiced patent system. Importing countries' strong patent systems ensure exclusive rights over the knowledge embodied in the products and services. Because others have no chance to imitate even if they have resources and imitation abilities, products and services cannot enter the market without being imported. As a result, trade increases to countries with a strong patent system. The other effect is the market power effect, in which an exporter decreases its exports to markets with a strong and well-practiced patent system. Because no chance exists for others to imitate even if they have resources and imitation abilities, the exporter can increase the unit price by reducing its volume of products and services. In short, many benefits exist to exporters in foreign countries with strong and well-practiced patent systems.

For such reasons, companies engaging in international business are motivated to apply patents in markets that are significant for these businesses. Companies that seek to enter foreign markets without patents will face significant risks, including risks that are much more significant in industries in which the patent thicket (Shapiro, 2001) is dominant. Moreover, international patent filings assist in understanding a corporate strategy (Faust & Schedl, 1983; Mogee & Kolar, 1994).

2.4 International distribution of SEPs: the GSM case

A historical event during the GSM standardization also provides insight (Shurmer & Lea, 1995; Iversen, 1999; Bekkers et al., 2002; Gandal et al., 2003).

As previously mentioned, GSM was developed as a regional standard in Europe to achieve significant economies of scale in equipment supply and to provide roaming services. However, when GSM systems' technical specifications were completed, the standardization committee recognized patent issues in all technical sections. Throughout the search, Motorola turned out to be the largest holder of GSM SEPs. That fact exacerbated the problems because Motorola refused to declare its licensing policy. Motorola gained the upper hand on cross-licensing of GSM SEPs for GSM implementation. In the end, Motorola entered into a cross-

license agreement with Alcatel, Ericsson, Nokia, and Siemens between 1990 and 1993, which represented an early stage of GSM service. Those who could not reach agreement faced a severe disadvantage. For example, most Japanese firms preparing to enter the GSM market could not do so for several years after GSM services were launched. As a result, a firm's business in the GSM market was determined by cross-licensing of GSM SEPs.

To the best of our knowledge, no study clearly provided evidence on the patent authorities in European countries that provided protection to the GSM SEPs held by Motorola. However, it is natural to speculate that patent family members[3] of Motorola's GSM SEPs were protected by at least one major patent authority in European countries and/or countries in which incumbent players from Europe had businesses. In general, firms in the United States were aware of the significant role of patents earlier than firms in other countries and, thus, strategically used patents. Motorola sought overseas business opportunities, and unless its GSM SEPs were protected in countries of interest, European firms had no need to cross-license GSM SEPs

3. Data

We retrieved the list of SEPs from the ETSI Special Report 000314 and focused on W-CDMA and LTE, which are recognized as the most globally successful technical standards in the mobile communications industry, and offer global services. The list of SEPs is reported in the 25 and 36 series in the ETSI Special Report 000314, including the W-CDMA and LTE specifications in 3GPP (3rd Generation Partnership Project). Readers must note that we dropped those SEPs for TD-SCDMA (TS 25.221, TS 25.222, TS 25.223, TS 25.224, and TS 25.225). TD-SCDMA is known as the 3G standard of China and is deployed only in the Chinese mobile communications market. Accordingly, by dropping the SEPs aimed at TD-SCDMA, we can correctly analyze the strategies deployed by Chinese firms in global markets.

[3] In this paper, a patent family is a group of patent filings that claim the same priority of a specific filing.

W-CDMA and LTE SEPs retrieved from ETSI Special Report 000314 matched those linked to patent data in the EPO PATSTAT patent database. One must note that the list of SEPs is reported on the basis of declarations by SEP owners. Thus, the list may represent over- or under-declaration (Bekkers & Updegrove, 2012). Because verification of the essentiality of SEPs requires technical expertise and no database exists that verifies "correct" SEPs, we believe that ETSI's database is the best one for a study such as this. Thus, we note this issue as a limitation of this study.

4. Findings

4.1 Number of essential patents owners by country in East Asia

The first analysis shows the SEP owners in W-CDMA and LTE. We count the number of firms that declared their SEPs in W-CDMA and LTE to ETSI, and the result is shown in Table 1.

Table 1. W-CDMA and LTE SEP owners in East Asia

China	Japan	Korea	Taiwan
Huawei ZTE	NEC NTT DoCoMo Panasonic Sharp Sony Toshiba	LG Electronics Samsung Electronics	ASUSTek BenQ HTC Innovative Sonic

We closely investigate each country. First, Huawei and ZTE are the only SEP owners in China. Compared with the number of firms in the telecommunications industry in China, the fact that only two firms exist for China may be disappointing. Huawei and ZTE are known as the two leading firms in the telecommunications industry in China. Because they explain more than 70% of the telecommunications industry in China when measured by delivery value of exports, gross industrial output value, and number of employed in the industry, the result is not surprising (Kang, 2015).

Japanese firms represent the largest SEP owner group among the four countries, and Japan has six corporate groups of W-CDMA and LTE SEP owners. As of late 2016, among

the five manufacturers from Japan, some of them withdrew from cellphone and smartphone manufacturing and decided to concentrate on network businesses. Another salient point is that NTT DoCoMo, the leading network operator in Japan, is one of the owners. Among all of the W-CDMA and LTE SEP owners in East Asia, NTT DoCoMo is the only network operator. NTT DoCoMo has been known as a leader in Japan's mobile communications industry (Kushida, 2011). Therefore, that NTT DoCoMo is a SEP owner is not surprising.

Korea is similar to China. Only two firms declared themselves as owners of W-CDMA and LTE SEPs. They are also the two leading firms in the telecommunications industry in Korea. Although the number of firms may seem very small, the share of W-CDMA and LTE SEPs owned by the two is very large (Kang et al., 2014).

Taiwan also shows differences from the other countries, and four firms declared their ownership of W-CDMA and LTE SEPs. Considering Taiwan's population and domestic market size, this number is quite large, possibly implying that interest in SEPs is widespread throughout society.

4.2 Disclosure of SEPs to the standard setting organization

SEPs are known through their owners' declarations because quite a few SSOs require firms to indicate a list of patents that would be infringed on by standard implementers. This subsection shows the frequency and number of SEP declarations made since 3GPP was formed. In no case were any of the declarations from Chinese, Japanese, and Korean firms made before 2002. The analysis in this subsection provides information regarding the identity of the key player, possible risks behind declarations, and other points.

Table 2 indicates the result regarding the number of disclosure events. A disclosure event refers to a SEP declaration from potential owners to a given SSO on a given date. A disclosure event may include multiple patents. For each year of the original disclosure statement submitted to ETSI, we calculated the number of disclosure events to ETSI regarding W-CDMA and LTE SEPs. Table 3 indicates the number of SEPs that were declared each year in Table 2.

Chinese firms made their first declaration of W-CDMA and LTE SEPs to ETSI in 2005. Since then, Chinese firms declared their SEPs every year. One outstanding feature is that the number of disclosure events increased in the late 2000s. Moreover, the number of declared

SEPs also began to increase in 2009 (Table 3), implying that Huawei and ZTE realized the importance of owning SEPs around 2010.

In 2004, Japanese firms made their first declaration of W-CDMA and LTE SEPs to ETSI. In the first half of the 2000s, although a large variation existed in the number of declared SEPs each year, Japanese firms constantly declared their potential SEPs. This fact implies that their participation in the 3GPP standardization has been constant for the last decade.

Korean firms made their first declaration of W-CDMA and LTE SEPs to ETSI in 2003. From the early stage of declaration, the number of SEPs declared was large. After two years of no SEP declarations, those firms resumed their declarations and, since 2006, have declared their SEPs every year. The total number of SEPs declared from Korean firms is the largest among the four countries.

Taiwanese firms made their first declaration of W-CDMA and LTE SEPs to ETSI in 2002, earlier than any other firm in East Asia. They consistently made declarations between 2001 and 2005. One difference from the Chinese, Japanese, and Korean firms is that the number of declared SEPs from Taiwanese firms is the smallest in our observation. In addition, after 2005, no SEP declarations were made except in 2007 and 2011. This finding implies that Taiwanese firms' participation in 3GPP became less active than before.

Table 2. Number of disclosure events to ETSI per year

	China	Japan	Korea	Taiwan
2001				
2002				2
2003			1	1
2004		2	1	1
2005	1	1		2
2006	1	2	2	
2007	1		1	1
2008	1	1	4	
2009	3	4	8	
2010	5	7	9	
2011	5	7	6	2
Total	**17**	**24**	**32**	**9**

Table 3. Number of SEPs declared to ETSI per year

	China	Japan	Korea	Taiwan
2001				
2002				135
2003			595	2
2004		356	286	5
2005	46	1		114
2006	108	573	553	
2007	22		120	18
2008	29	228	970	
2009	101	1873	2805	
2010	330	1414	840	
2011	253	1264	964	360
Total	**889**	**5709**	**7133**	**634**

4.3 Geographical protection of essential patents owned by East Asian firms

This subsection indicates how their SEPs counted in the previous section (Table 2 and Table 3) are protected from a geographical point of view. Because patents are territorial, SEP owners cannot claim their ownerships over SEPs in countries in which the owners did not file their SEPs. Accordingly, SEPs must be filed with the patent authorities that applicants consider as being in important markets. For this reason, analyzing geographical protection will assist in understanding the countries that are considered significant (or not significant) for SEP owners.

Meanwhile, according to ETSI's IPR policy, SEP owners are obliged to disclose one member of a patent family (ETSI, 2013). Disclosure of other patent family members is voluntary. Accordingly, we are unable to find all patent family members for each SEP from ETSI Special Report 000314. Therefore, we found all patent family members of each SEP by matching each SEP to the patent data in the EPO PATSTAT patent database using the definition of the DOCDB.[4] Table 4 shows the result.

Table 4. Patent authorities for which W-CDMA and LTE SEPs are protected by East Asian firms

[4] Several approaches exist to defining a patent family. For the benefits and challenges related to DOCDB and INPADOC patent families, see WIPO (2013).

China	Japan	Korea	Taiwan
Asia: CN, HK, JP, KR Europe AT, DE, DK, ES, FI, PT North America: CA, US Others: AU, BR, MX, RU	Asia: CN, HK, ID, JP, KR, MY, SG, TW Europe AT, CZ, DE, DK, ES, FR, NO, PL, PT, SE, UK North America: CA, US Others: AU, BR, MX, RU, ZA	Asia: CN, HK, IN, ID, JP, KR, MY, SG Europe AT, DE, DK, CY, ES, FI, FR, IT, PL, PT, SE, SI, UA, UK North America: CA, US Others: AR, AU, BR, IL, MA, MX, RU, ZA	Asia: CN, JP, KR, TW Europe AT, DE, ES, North America: US Others: AU

As was done in prior subsections, we again closely investigate each country. SEPs owned by owners from China are protected in 16 authorities. They are patent authorities in either high-income economies or major emerging economies. This finding implies that Chinese firms consider high-income and major emerging economies as significant markets for their global businesses. However, evidence has shown that China's standard strategy is to concentrate on their own standards, which are primarily aimed at domestic markets, rather than follow global standards (Lee & Huh, 2012; Kang et al., 2014). In this sense, the risk might be small as far as Chinese firms playing on top of China standards. Protecting SEPs in not enough patent authorities appears risky when Chinese SEP owners attempt to expand their international businesses to other middle-income economies. Especially now, a significant possibility exists that China will not have its own 5G standard and the market will be completely globalized. Hence, the risk might be more significant than before for Chinese firms.

SEPs owned by owners from Japan are protected in 26 patent authorities. Patent authorities for which their SEPs are filed are mostly in high-income economies.[5] Among the 26 economies are five non-high-income economies: Brazil, China, Mexico, Russia, and South

[5] For an overview of the classification of countries by income level, see Felipe et al. (2012), who re-classified using the definition of the World Bank and their own calculation.

Africa. Of the five non-high-income economies, four (Brazil, China, Russia, and South Africa) are well recognized as BRICS countries and major emerging middle-income economies. From this finding, we can assume that SEP owners in Japan consider high-income economies and major emerging economies for their market size.

Meanwhile, SEPs owned by firms from Korea are protected in 32 patent authorities. They file their SEPs not only in high-income economies but also in five upper-middle-income economies (Malaysia, Mexico, Poland, Russia, and South Africa) and five lower-middle-income economies (Brazil, India, Indonesia, Morocco, and Ukraine). In other words, both developed and developing economies are important markets for Korean firms. Korean firms and the government in the 1960s were considered a typical example of having an export-oriented attitude (World Bank, 1993) and were famous for their awareness of overseas markets (Kim, 1997). That finding in Table 4 implies that Korean firms' export-oriented attitude appears even during the standardization process. In Table 4, their export-oriented tendency appears to be the most outstanding among the four East Asian countries.

Lastly, SEPs owned by owners from Taiwan are protected in nine patent authorities that are in only high-income economies. Even if Taiwanese firms are also known for their export-oriented economy, we assume that their interest is very much focused on high-income economies.

4.4 East Asian firms' international protection of SEPs

As previously argued, SEPs are protected globally and strategically. How is East Asian firms' international protection of SEPs? To address this question, we constructed a dataset of all SEPs applied to the USPTO. The observation size is 3,975, which is smaller than the sum of Table 3 because the same patents applied to different patent authorities are declared individually when declared. However, in the regression analysis, we used only SEPs applied to the USPTO.

We use patent data applied to the USPTO because of the significance of the U.S. market in international business. Patent applications are subject to the tradeoff between dominance and cost. Because of the U.S. market's global significance, companies doing international business apply for patents in the United States and accept the high cost.

We constructed a negative binomial regression because the dependent variable is a count number: 1 subtracted from the number of patent authorities to which a SEP is applied. By subtracting 1, patent applications filed in only one patent authority is set to 0. We calculated this variable using the DOCDB patent family. The independent variables are four national dummy variables: China, Japan, Korea, and Taiwan. Accordingly, the baseline in this regression model is non-East Asia, i.e.,., Canada, Europe, and the United States, and we add control variables to the regression analysis. The first control variable is normalized forward citations, which is added as a proxy for a patent's technological value. We presume that technologically important SEPs are protected by more countries than less important SEPs. This variable is obtained by dividing the number of forward citations by the average number of forward citations from the same application year and international patent classification (IPC) (Jaffe & Trajtenberg, 2002).[6] We use only U.S. patent citations when measuring the number of forward citations. The number of forward citations increases if an applicant of a forward citation files patent family members in more than one country, and the chances are higher that a patent will receive more citations from each of the patent family members. Using U.S.-to-U.S. citation analysis allows such an adverse causality to be avoided. The second control variable is the logarithm of the total patent stock of the applicant. This variable is added as the size of the applicant. We presume that firms with a large patent portfolio tend to file their patents internationally. The third control variable is a prior application year dummy. The value of the year dummy is set to 1 according to the prior application year of each patent application.

Table 5 shows the results, including coefficients and t-statistics. The four countries (China, Japan, Korea, and Taiwan) have negative effects and negative statistical significance at the 1% level in all regression models. This result indicates that their SEPs are less likely to be protected internationally compared with firms from Canada, Europe, and the United States. Comparison of the coefficients between the four countries implies that SEPs held by Chinese firms are the least protected internationally and those held by Japanese firms are more protected internationally. In addition, all control variables showed the result we presumed.

[6] Old patents are probably cited more frequently than recent patents, which become a bias in patent citation analysis. Normalization is necessary to eradicate such a bias.

That is, inventions with better technological value and that were invented by larger firms tend to be protected in a larger number of patent authorities.

Table 5 Regression result

(DV: 1 subtracted from the number of patent authorities to which a SEP is applied)

	1	**2**	**3**	**4**	**5**
CN	−0.5999	−0.5838	−0.6423	−0.6256	−0.6383
	[−5.45]***	[−5.30]***	[−5.74]***	[−5.59]***	[−5.70]***
JP	−0.2864	−0.2765	−0.3103	−0.3	−0.298
	[−7.98]***	[−7.68]***	[−8.24]***	[−7.94]***	[−7.83]***
KR	−0.4094	−0.4022	−0.4626	−0.4546	−0.4614
	[−12.61]***	[−1237]***	[−11.21]***	[−11.00]***	[−11.17]***
TW	−0.5007	−0.4922	−0.4481	−0.4406	−0.4409
	[−4.30]***	[−4.23]***	[−3.77]***	[−3.71]***	[−3.70]***
Normalized forward citations		0.0084		0.0084	0.0076
		[2.85]***		[2.82]***	[2.54]***
Log(Patent stock of applicant)			0.0227	0.0224	0.023
			[2.10]**	[2.06]**	[2.09]**
Application Year	No	No	No	No	Yes
Constant	2.0507	2.032	1.8657	1.8501	1.9608
	[128.83]***	[118.71]***	[20.84]***	[20.60]***	[13.87]***
N	3975	3975	3975	3975	3975

* p<0.1, ** p<0.05, *** p<0.01

The following figures provide a better sense of the regression analysis. The figures indicate the average number of patent authorities for which W-CDMA and LTE SEPs are protected by firms in each region. The calculation is done by taking the average of the number of patent authorities with which each firm in each country filed their SEPs and further taking the average of each firm's value. For example, the bar in 1993 in Figure 1 implies that a firm in Japan filed its SEPs in an average of 12 patent authorities. Figures 1 and 2 show the case of East Asian countries, whereas Figure 3 shows the case of the United States and Europe as references.[7] The horizontal axis represents the application year.

[7] The case of Canada is not shown for brevity. However, the data can be provided on request.

In Figure 1, China's average number of patent authorities varies between 4.4 and 8, whereas Japan's average ranges from 3.7 to 12. Japan's case shows that value modestly increases over time, which is not observed in China's case. It can be presumed that recognition regarding the importance of international SEP protection increased in firms in Japan.

In Figure 2, Korea's average number of patent authorities varies between 1 and 8.4, whereas Taiwan's average number ranges from 3.3 to 7.8. Korea shows an increase until 2002 and then a subsequent decrease. In contrast, Taiwan shows a trend similar to Japan.

In Figure 3, the average number of patent authorities for the United States varies between 4.7 and 14, whereas Europe's average number ranges from 3 to 10.3. Figure 3 does not show any apparent trend—no evident increase or decrease. Rather, salient ups and downs are shown. Nonetheless, the values of the United States and Europe are larger than the values of any of the four East Asian countries. Perhaps the importance of international SEP protection is much better recognized by firms from the United States and Europe.

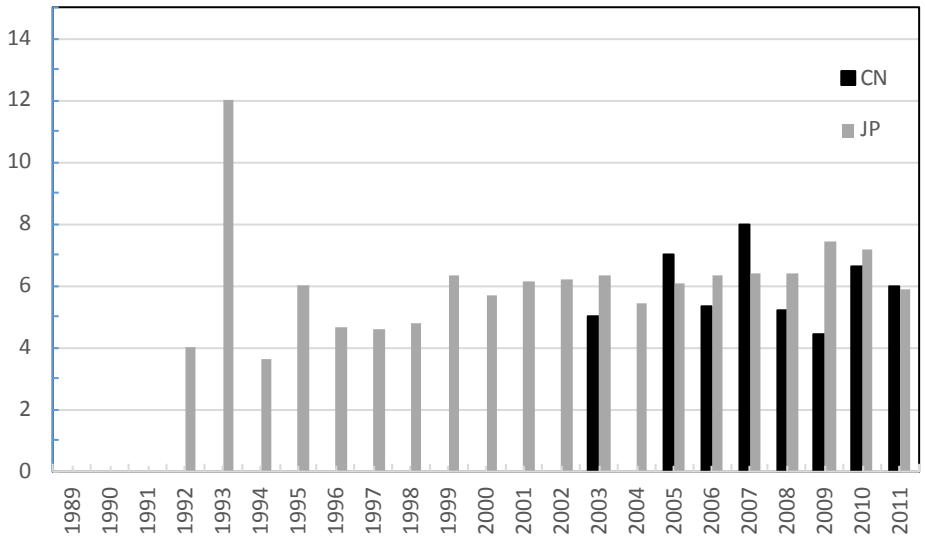

Figure 1. Average number of patent authorities for which SEPs are protected: China and Japan

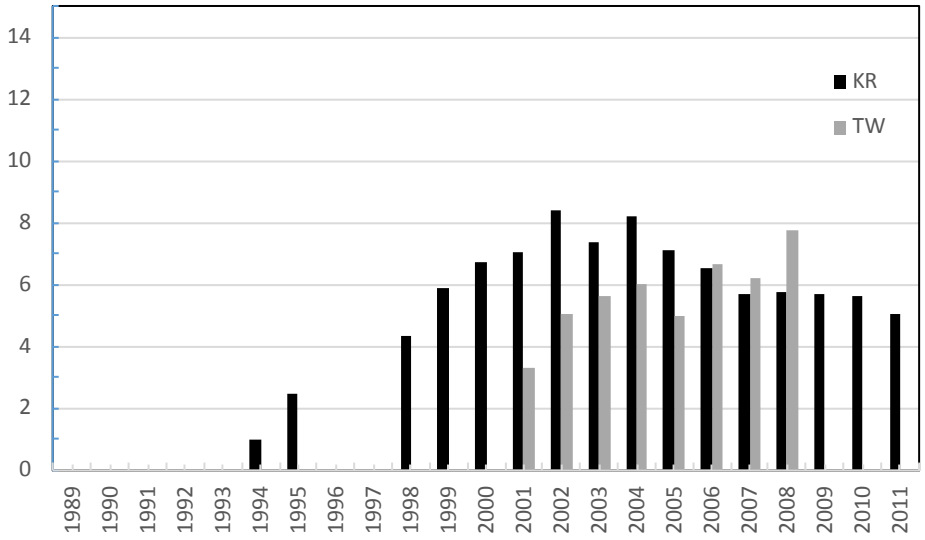

Figure 2. Average number of patent authorities for which SEPs are protected: Korea and Taiwan

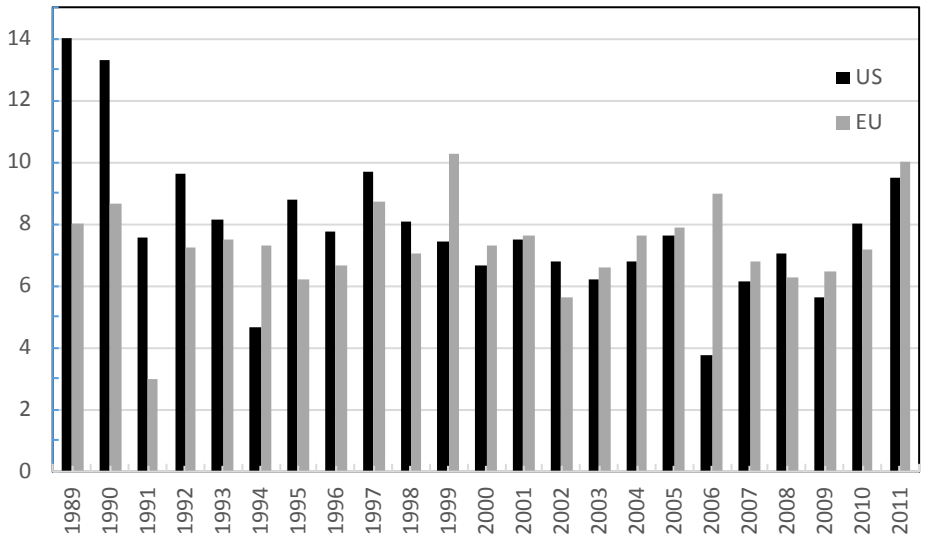

Figure 3. Average number of patent authorities for which SEPs are protected: United States and Europe

5. Discussion

The findings are summarized and further discussed in this section. First, the protection strategy of W-CDMA and LTE SEPs by East Asian firms is different among countries, which can be summarized as follows.

(1) China: As found by other studies, Chinese firms' have actively participated in global standardization, as have Japan and Korea recently. However, their SEP protections are concentrated only in developed countries and major developing countries, such as some of the BRICS.
(2) Japan: Japanese firms' participation in global standardization is the most constant. The number of Japanese firms that have ever had W-CDMA and LTE SEPs is the largest among the four East Asian countries. The protection of their W-CDMA and LTE SEPs are concentrated in high-income economies.
(3) Korea: Korean firms have their SEPs in many countries from high-income to middle-income economies. In addition, the number of declared SEPs is largest among the four countries.
(4) Taiwan: What was outstanding was the number of firms that own SEPs. Compared with Chinese and Korean companies, more Taiwanese companies own SEPs and some of them are non-manufacturers. However, their declaration has become less inactive in the late 2000s than in the early 2000s. As seen in Japan, Taiwanese firms' protection of their W-CDMA and LTE SEPs are also concentrated in high-income economies.

Second, our regression analysis showed that SEPs owned by East Asian firms tend to be protected in fewer countries after controlling for the determinants of the global protection of SEPs.

Our findings provide several implications, including implications for each country based on the previously described findings, as follows.

(1) China: Chinese firms will face difficulty operating their businesses globally, especially in developing countries. Domestic firms that have businesses on China's own standard will face two challenges. First, they will generate additional costs to operate businesses on the

global standard. As discussed in other studies, China's focus has been in setting its own standard rather than following the global standard (Lee & Huh, 2012; Kang et al., 2014). The costs to accrue different technological knowledge and to construct supply channels regarding the global standard must be paid. Second, even if China pays such costs, it will not be easy operating a business in countries in which only rivals have relevant SEPs and it does not. In this situation, China will always face infringement issues with rivals.

(2) Japan: The fact that Japanese firms own W-CDMA and LTE SEPs implies that many such firms are much more aware of the value of SEPs. Their global business in the mobile communications industry was concentrated in developed countries. In this sense, they were going to have difficulty doing business in developing countries. However, as mentioned in Section 4.1, many of them withdrew their cellphone and smartphone businesses. Thus, the question remains as to how the W-CDMA and LTE SEP owners use their SEPs after shutting down their businesses in the mobile communications industry. If their SEPs are sold to any third party, is the new buyer willing to license the SEPs in the fair, reasonable, and non-discriminatory (FRAND) way?

(3) Korea: The country's SEP protection behaviors imply that its business interest is global, from high-income economies to numerous middle-income economies. Among the four countries, Korean firms are most active in owning SEPs, which implies that they consider SEPs an important asset for their business. Their protection behavior can be a model for following firms that consider operating a business in a standard-based industry. A remaining issue is how well the patent system is effectively practiced in developing countries.

(4) Taiwan: The number of Taiwanese firms that own SEPs implies that their interest in SEPs is widespread in society compared with China and Korea. However, their interest in SEPs has become much less than before. Therefore, as questioned in the case of Japan, an issue remains as to how W-CDMA and LTE SEP owners use their SEPs.

Three implications exist for companies that operate businesses internationally. First, SEPs have the potential to function as a trade barrier. Knowing the countries in which SEPs in interested standards are protected is very important because such knowledge hints at an

understanding of rivals' international business strategies and the countries that represent opportunities for, or threats to, exporting.

Second, as our regression analysis shows, technologically advanced SEPs are more likely to be protected in many patent authorities. If a SEP is filed not only in major markets but also in minor markets, the SEP is likely to contain technologically advanced inventions. Accordingly, there is almost no chance that the SEP can be invalidated during patent lawsuits. This study analyzed SEPs in only two standards: the representative 3G and 4G standards in the mobile communications industry. Other standards exist in the same industry, as do a large number of other standards if we count other industries. One must pay attention to the global distribution of SEPs in relevant standards.

Third, the next implication is the significance of the strategic ownership and protection of SEPs for non-SEP owners. As shown in this study, SEPs are protected globally. A number of prior studies discussed the FRAND license and proposed amendments and alternative methods (Lemley, 2002; Chiao et al., 2007; Farrell et al., 2007). However, nothing has been achieved in actuality because the FRAND royalty cannot be calculated or verified theoretically. Additionally, this royalty cannot be calculated before or after market formation, and the FRAND way depends on the situation and varies on a case-by-case basis, and so on. In other words, no universally practical licensing policy exists that non-SEP owners can expect from administrative organizations. In this situation, the minimum preparation is to become a SEP holder by participating in standardization or by purchasing. By doing so, one can demand reciprocity in licensing with existing SEP holders.

6. Conclusion

This study investigated how W-CDMA and LTE SEPs owned by East Asian companies are protected globally. We showed that the protection strategy of these SEPs is different between countries within East Asia. We further tested the tendency of East Asian firms' international SEP protection and discussed the protection strategies of W-CDMA and LTE SEP holders by East Asian firms.

The limitations to this analysis should be noted. First, this paper used only the case of SEPs in W-CDMA and LTE standards as typical in the mobile communications industry. The

distribution of SEPs must be much more complex considering that SEPs exist in other standards in the other industries, and the IPR policy of a SEP is defined in different ways. Thus, the applicability of the findings to other studies remains an unsolved issue. Second, the data used in this study may not represent all SEPs. SEPs are known through declarations by their owners. Accordingly, there might be SEPs that are not declared. In addition, SEPs are a tradable asset and can be transferred to third parties that are not members of SSOs. For third-party SEP owners, declaring a SEP is not an obligation. For instance, ETSI's obligation to inform about SEPs is applied only to its members and not to third parties (ETSI, 2013). Accordingly, other third parties may have undeclared SEPs that can function as a trade barrier.

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Appendix: Overview of correlations between variables in regression of Table 5

	v1	v2	v3	v4	v5	v6
CN	1					
JP	-0.0536	1				
KR	-0.064	-0.2242	1			
TW	-0.0142	-0.0499	-0.0595	1		
Normalized forward citations	-0.0394	-0.0664	-0.0571	-0.0118	1	
Log(Patent stock of applicant)	0.097	0.1432	0.5632	-0.1997	-0.0547	1