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Innovation Networks in China, Japan, and Korea: Further Evidence from U.S. Patent Data

Kaoru NABESHIMA and Kiyoyasu TANAKA*

April 2011

Abstract

The growing importance of innovation in economic growth has encouraged the development of innovation capabilities in East Asia, within which China, Japan, and Korea are most important in terms of technological capabilities. Using U.S. patent data, we examine how knowledge networks have developed among these countries. We find that Japan's technological specialization saw gradual changes, but those of Korea and China changed rapidly since 1970s. By the year 2009, technology specialization has become similar across three countries in the sense that the common fields of prominent technology are electronics and semiconductors. Patent citations suggest that technology flows were largest in the electronics technology, pointing to the deepening of innovation networks in these countries. Together with our prior work, the Japanese and U.S. data produce similar conclusions about innovation networks.

Keywords: Innovation Network, Patent Statistics, China, Japan, Korea
JEL classification: O31, O33, L6

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* Corresponding author: Kiyoyasu Tanaka. Address: Inter-Disciplinary Studies Center, Institute of Developing Economies, 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba 261-8545 Japan. Phone: 81-43-299-9755; Fax: 81-43-299-9763. E-mail: kiyoyasu_tanaka@ide.go.jp

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INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

Innovation Networks among China, Japan, and Korea: Further Evidence from U.S. Patent Data*

Kaoru Nabeshima[a]

Inter-Disciplinary Studies Center, Institute of Developing Economies

Kiyoyasu Tanaka[b]

Inter-Disciplinary Studies Center, Institute of Developing Economies

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Abstract:

The growing importance of innovation in economic growth has encouraged the development of innovation capabilities in East Asia, within which China, Japan, and Korea are most important in terms of technological capabilities. Using U.S. patent data, we examine how knowledge networks have developed among these countries. We find that Japan's technological specialization saw gradual changes, but those of Korea and China changed rapidly since 1970s. By the year 2009, technology specialization has become similar across three countries in the sense that the common fields of prominent technology are electronics and semiconductors. Patent citations suggest that technology flows were largest in the electronics technology, pointing to the deepening of innovation networks in these countries. Together with our prior work, the Japanese and U.S. data produce similar conclusions about innovation networks.

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[a] Senior Researcher, Inter-Disciplinary Studies Center, Institute of Developing Economies, Institute of Developing Economies; E-mail: Kaoru_Nabeshima@ide.go.jp

[b] *Corresponding author*: Inter-Disciplinary Studies Center, Institute of Developing Economies; address: 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba 261-8545, Japan; E-mail: Kiyoyasu_Tanaka@ide.go.jp

1. Introduction

In recent decades many countries have focused on nurturing innovation capabilities as a component of growth strategies since technological innovation has become the main driver of economic growth.[1] National governments have implemented a variety of science and technology policies, including public investment in education, direct subsidies for research, and institutional protection of innovation so as to build up technological and innovation capabilities. The development of innovation capability at home remains to be a crucial area for public policies. Especially, middle income countries have increasingly placed an emphasis on the technological capabilities for growth strategies.

Within this context, technology flow is a key component when domestic technological capabilities are to be strengthened.[2] In the past, innovation was characterized as a "closed" activity within an entity such as R&D laboratories owned by a large corporation. By contrast, innovation activities are now becoming more "open" than ever before in the sense that influential innovation is produced through collaboration among several entities such as business firms, universities, and research institutions. This trend is sensible partly because the pace of technological change has accelerated in the recent years and current innovation is complex in technology and straddles over diverse disciplines. Consequently, the need for collaboration highlights the development of knowledge and innovation networks, which are now global in scope for the economic globalization (Picci 2010).

In this paper, we use US patent data to examine how knowledge networks have developed among China, Japan, and Korea for 1976-2009. Many economies in East Asia are keen on developing technological capabilities and attempt to shift its economy to more knowledge-based economy.[3] Within East Asia, three countries – China, Japan, and Korea (hereafter, CJK countries) are most important in terms of technological

[1] For instance, see Yusuf and Nabeshima (2010) on the need to develop technological capabilities to sustain rapid growth in Southeast Asia region.
[2] Li (2010) finds that removal of diffusion barriers associated with technology flow have much larger welfare gains relative to removal of trade barriers.
[3] For instance, on knowledge economy, see Dahlman and Aubert (2001) on China; Shibata (2006) on Japan; Suh and Chen (2006) on Korea; World Bank (2008) on Thailand; and World Bank Institute (2007). for developing countries in general.

capabilities. Japan and Korea are now technological leaders in Northeast Asia while China is very rapidly catching up on the technology ladder. Together, CJK countries are the engine of the global economy. Given the current discussion on forming a free trade agreement in this region, CJK countries can provide a fertile ground for the development of knowledge networks.

However, a quantitative assessment of innovation networks is a challenging task mainly for the intangible nature of knowledge flows and inventive activities. There is no perfect quantitative measure of what technological contents move across countries and how much such technological flows are facilitated by international networks. In this lack of data, bibliographic information contained in patents is one of the few data sources which can trace knowledge flow with objectivity. By definition, a patent is a document that an authorized government institution issues for an inventor to grant the exclusive right of the use of invention on the basis of the novelty and potential usefulness of the invention. As such, Griliches (1990) argues that patent statistics are good indicators of successful inventive activity. Furthermore, patent citation information represents the identity and content of existing knowledge used to produce the invention, which allows us to quantitatively examine a linkage between patented innovations (Hall, Jaffe and Trajtenberg 2001), the patent citation.

In our previous paper, we employed the Japanese patent data for analysis (Ikuo, Nabeshima, and Tanaka, 2011). The Japanese data are advantageous in that the patent records are likely to represent the inventions made in Japan, which are usually applied first at the Japanese patent office. However, the pattern of patent applications and citations would be likely to reflect the technological strength in Japan, so that the data source could influence our measure of innovation networks among CJK countries. Thus, the use of Japanese patent data contains a possible bias of Japan's technological capability. To address such a concern, this paper uses the U.S. patent data as an arguably objective source of patent records. Because the U.S. data are less subject to the Japan's bias, we can provide a more objective analysis than that using the Japanese data.

This paper also addresses the question of whether we can reach the similar conclusions about innovation networks among CJK countries using the different data sources of patents which are granted under a distinctively different patent system. It is well known that the Japanese and U.S. patent systems are quite distinctive in the examination process. For instance, the patent right is granted to the first applicant in Japan, but the first inventor in the U.S. The scope of individual claims for an invention was narrower in Japan than in the U.S. Also, the Japanese patent law was revised to allow for multiple claims in one patent in the 1988 reform.[4] Because patent records are based on these distinctive patent systems, the analysis could differ in important dimensions when the U.S. patent data are used.

Our key findings can be summarized as follows.[5] First, all three countries saw its technological specialization change since 1970s. Changes in Japan's technological specialization were gradual, but those of Korea and China changed rapidly since 1970s. By the year 2009, technology specialization has become similar across three countries in the sense that the common field of prominent technology is "electronic circuits and communication technologies", "electronic components and semiconductors", "measurement, optics, and photography", "display, sound, information memory", and "clock, controlling, calculator". Second, this convergence in specialization suggests that technology flow among these three countries would be largest in the electronics and semiconductors technology. An analysis of patent citations confirms that the most active field of patent citation occurred in the electronics technology.

Our prior work uses Japanese patent data to provide the similar findings about the development in innovation networks across CJK countries. These results improve the credibility of our analysis using patent statistics in the sense that patent data sources and patent systems are not influential in determining our measure of innovation capabilities and knowledge networks across borders. This conclusion is similar to Sakakibara and Branstetter (2001) who uses both Japanese and U.S. data for investigating the effect of patent system on innovation.

The rest of this paper is organized as follows. Section 2 explains the data on U.S. patents with a basic description of patent data. Section 3 illustrates technology

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[4] Sakakibara and Branstetter (2001) employs both Japanese and U.S. patent data to study a link between patent scope and innovation.

[5] In Kuroiwa, Nabeshima and Tanaka (2011), they use patent data from the Japan Patent Office (JPO). One concern of conducting analysis based on JPO data is the bias towards Japanese firms relative to Chinese and Korean firms. By using US data, we can avoid such bias. To the extent that the US is one of the top trading partners of CJK countries, firms also would have incentives to patent in the US.

specialization in China, Japan, and Korea. Section 4 describes a pattern of patent citation to examine innovation networks among CJK countries. Section 5 concludes.

2. U.S. Patent Data

The U.S. patent database comes from the U.S. Patent and Trademark Office (USPTO) distributed through Google.[6] It contains the bibliographic information on all patents granted by the USPTO from 1976 onward. From 1976 to 2001, the data is based on the data retrieved from magnetic tape. Each line begins with data elements to signify the content of the line. The explanation of the data structure can be found in the "United States Patent & Trademark Office Patent Full-Text/APS (aka "Green Book").[7] From 2002 onward, the data are provided by a file formatted using XML with various incarnations. These files were processed using PERL to parse through text files to make usable data base.[8] However, the older data contained many mistakes regarding application and grant years. We corrected for these by verifying them with the actual patent document. As a result, there are 3,693,144 invention patents (utility patents in USPTO) (see Table 1).

<<TABLE 1 >>

Our main interest lies in the citation data, which we use as the measure for technology flow across borders. In assigning the "nationality" of a patent, one can use the registered residency of either applicants or inventors. We use residency of the assignee as the nationality of a patent since these are the entities that organized the innovation activity. However, for some observations, this information is missing. We parsed the address field and assigned ISO two-character country codes to each patent for observations missing country codes.[9] Because some of the records did not have

[6] Researchers can download the raw patent data provided by the USPTO from the following address accessed as of August 2010: http://www.google.com/googlebooks/uspto-patents-grants-biblio.html
[7] This is available from http://commondatastorage.googleapis.com/patents/docs/PatentFullTextAPSDoc_GreenBook.pdf.
[8] We thank Masato Kuroko for helping us to write PERL programs.
[9] In addition, we replaced the country codes used by the USPTO to be ISO two-character country codes. For instance, Japan was classified as "JA" in older data where it should be "JP". Similar kinds of revisions to data were made to other countries.

address data, excluding these samples reduced the dataset to around 3.14 millions observations.

Before proceeding to analyze innovation networks, we present the basic fact about the patent data used. Figure 1 shows the trend in patents granted by the USPTO, which are further broken down by the nationality. The number of patents granted steadily increased from 56,708 in 1976 to 152,242 in 2009. In 2009, 49.3% of patents were registered to U.S. residents and the rest to foreign applicants. Of the foreign applicants, Japan's share was 44.9%, Korea's 11.2%, and China's 0.8%. Since 1976, the number of patents granted to Japanese residents increased steadily. The rate of increase of patents granted to Korean residents is astonishing. From 1980 to 2009, the average rate of increase was 40.4%. Similarly, the pace of the number of patents granted to Chinese residents started to accelerate after the middle of 1990s.[10]

<<FIGURE 1 >>

To shed light on the important nationalities, we illustrate the top 10 countries in terms of the number of patents applied, which are tabulated in Table 2. In 1976, among the foreign applicants, those from the Japan accounted for more than one quarter of patents granted to foreign residents, followed by Germany, and U.K. All of the top 10 foreign applicants were from OECD countries. The situation did not change much in 1980 and 1990, except for the fact that the share of Japan increased steadily and in 1990, more than half of patents granted by the USPTO were assigned to residents of Japan. By 2000, however, the situation has changed dramatically. Korea now appeared in the top 10 along with Taiwan. Since then, the number of patents granted to Korean residents increased dramatically and Korea ranked the second among foreign applicants along with Taiwan at the 4th in 2009. During this period, China has never been ranked in the top 10.

<<TABLE 2>>

[10] See Hu and Mathews (2008) on the trend of Chinese patents.

3. Patterns of Technology Specialization

We turn to describe a pattern of technology specialization as measured by technology class of patents granted. Before presenting the results, Table 3 provides the number of patents granted across technology classification. There are 33 classes of technology to which the patents belong.[11] We count the total number of patents granted to applicants who resided in China, Japan, or Korea since 1976. Table 3 shows the figure of patents across technology classes together with the title of technology.

Figure 2 shows the result for Japan. In terms of patents granted to Japanese nationals in 1970s, Japan's strength lied in "measurement, optics, and photography" followed by "electronics components, semiconductors".[12] In 1980s, technological specialization by Japan did not change much from 1970s, still featuring "measurement, optics, and photography" and "electronics components, semiconductors" as the two most active patenting fields. The technological specialization of Japan in 1990s shifted towards "electronics components, semiconductors" as the most dominant field, followed by "measurement, optics, and photography". In addition, more patents were granted to "electronic circuits, telecommunications", "clock, controlling, calculator", and "display, sound, information memory." In 2000s, the technological specialization saw little change, but the shares of these five technology fields accounted for two-thirds of patents granted to residents of Japan, compared to 59% in 1990s.

<<FIGURE 2 >>

Figure 3 presents the result for technology specialization of patents granted to Chinese residents. In 1970s, there was no patent issued to Chinese residents by the USPTO. In 1980s and 1990s, the patents granted by Chinese residents belonged to the technology class in "electronics components, semiconductors", accounting for 15% of

[11] See Goto and Motohashi (2007) for the mapping between these 33 technology classes and corresponding international patent classification (IPC).

[12] In this section, we use application year as the indicator for time. The reason is twofold. First, patent grant year is typically two to three years behind that of application year. The lag in approval process depends on the workload of the patent office. To accurately gauge when the technology was invented, it is better to look at application year since application year is more reflective of the technological capabilities at that time.

patents granted to Chinese residents. China's specializations in 2000s were in "electronics components, semiconductors" and "electronic circuits, telecommunications". Relative to other fields, these are the strongest technological fields of China, which accounted for one-third of patents granted to Chinese residents.

<<FIGURE 3 >>

We turn to examine the technology specialization for Korean residents in Figure 4. In 1970s, there were too few patents granted to Korean residents to firmly determine their technological specialization. However, in 1980s, technology specializations of residents of Korea have become apparent. Already in 1980s, Korea's specialization lied in "electronics components, semiconductors" and "electronic circuits, telecommunications" followed by "display, sound, information memory".[13] This is followed by "display, information storage, and instruments" and "electronics circuits and communication technologies". Together, these three technology field account for 60% of patents granted to Korean residents, reflecting the rapid industrial development in electronics, telecommunication equipment, and information technologies in Korea.

<<FIGURE 3 >>

In the 1990s, Korea's patent fields were the same as in 1980s, "electronics components, semiconductors" followed by "electronic circuits, telecommunications" and "display, sound, information memory". In addition, the shares for "measurement, optics, and photography" and "clock, controlling, calculator" have also increased. The share of these five fields together accounted for 76%. It seems that patents granted to Korean residents were concentrated on these five fields relative to the others. Furthermore, technological specialization in Korea started to change in 2000s. While "electronics components, semiconductors" and "electronic circuits, telecommunications" were still at the top spots, the shares for "measurement, optics,

[13] The rapid development of electronics and semiconductor industries in Korea and East Asia has been examined by many researchers. See for instance, Mathews and Cho (2000), Kim (1997), and Hobday (1994).

and photography” and “display, information storage, and instruments” were rapidly increasing, suggesting a shift of Korea’s technological capabilities in the recent decade.

<<FIGURE 4 >>

An examination of technology specialization demonstrates that technology specialization has become quite similar among these countries. Japan’s technological specialization changed gradually from 1970s to 2000s, but Korea’s specialized fields have changed dramatically since 1980s, which seems to be still evolving. Korea started to receive a large number of patents in electronics and telecommunications fields after 1980s. Since then, Korea has focused its efforts in electronics, semiconductors, and telecommunication equipment, and now extending its strength in display and optics. As a result, Korea’s technology specialization mirrors that of Japan.[14]

Similar to the technological development of Korea, China’s strength lies in “electronics components, semiconductors” and “electronic circuits, telecommunications” while China seems to be nurturing capabilities in “measurement, optics, and photography”, “display, sound, information memory”, and “clock, controlling, calculator”. These fields of technology appear to converge to the technological specialization in Japan and Korea. Given that Korea’s and China’s technological specialization is quite similar to that of Japan, we expect that technology flows will be more active among the CJK countries in these five technology fields.

4. Patterns of Patent Citations

In order to gauge the extent of technology flow among these countries, we turn our attention to patent citations, which are contained in the patent database. We connected the basic patent information to citing and cited patents, including the nationality of patents based on residency. Overall, there are 40 million citing-cited pair observations.[15] Figure 5 shows the trend in average citations per patent since 1971, with the application

[14] The specialization pattern of patents granted to Korean residents is more apparent than that of Japan. Similar kind of pattern was seen in the patent data from Japan (see Kuroiwa, Nabeshima and Tanaka 2011).

[15] Each patent can cite multiple patents (“prior art”). Citations are limited to domestic (meaning citing only US patents) invention patents.

year used as the indicator for time. In the past, the average citation was just one or two. However, the number of citation has increased dramatically in the recent years. On average, a patent cites 15 other patents in 2009. While the number of citations seems to decease in the most recent years, this is mostly due to the lag in approval process and citation lags.

<<FIGURE 5>>

Figure 5 also show the number of citations made to patents registered to Chinese, Japanese, and Korean residents, along with the overall trend and citations made to U.S. resident for illustration. From the figure, the citations made to Japanese patents increased at slower pace than the overall trend. A similar trend can be seen for patents granted to Korean residents at lower level compared to Japan. Citations made to Chinese residents did not change much during this period of time.

For a further examination of patent citations, Figures 6 to 8 presents a difference among nationalities of citing patents. First, Japanese patents tend to cite other Japanese patents, as shown in Figure 6. The trend is similar to that of overall trend in that the number of citations is increasing. Japanese patents also cite U.S. patents often, but the frequency of citing Korean patents is now increasing rapidly, signifying the improvement in technological capabilities of Korean patents. Citation frequency to Chinese patents did not change during these periods. Second, Figure 7 indicates the results for citations of Chinese patents. While the figure is noisy, it indicates that the Chinese patents predominantly cite US patents, which seldom cite patents registered to residents in China, Japan, and Korea. Finally, Figure 8 shows that Korean patents cite Japanese and U.S. patents almost equally, although U.S. patents tend to be cited slightly more frequently. The number of citations made to Korean patents grew but at rather slow pace. Korean patents hardly cite any Chinese patents.

<<FIGURE 6, 7, 8>>

Figure 9 shows the trend in citations that are made to non-US patents since 1970. Similar to the overall trend, the citations made to non-US patents are increasing, reflecting the fact that knowledge flow is becoming more internationalized. In the latter year the citation seems to be decreasing. This could be due to the citation lag.

<<FIGURE 9>>

We turn to examine the role of CJK patents in accounting for citation patterns. In so doing, we measure how much of the "foreign" patent citation comes from "CJK" countries. For instance, we measure how much of the technology of a Chinese patent is derived from patents granted to Japan and Korea among citations made to non-Chinese patents. The results are shown in figure 10. For Japanese patents, the share of Chinese and Korean patents in citations made to non-Japanese patent is quite small. However, it appears that the trend is increasing, especially after mid 1990s. For Korean patents, the share of citations made to China and Japan (but predominantly Japan) is a significant portion, accounting for 40% of the foreign citations. Similarly for China, the citations made to Japan and Korea account for 20% of foreign citations. It is understandable that citations made by Japanese patents to Chinese and Korean patents are low at this stage since Japan leads the other two countries in terms of technological capabilities. Even so, the importance of technology developed by Chinese and Korean residents is on the rise. For Chinese and Korean patents, Japan gained in importance significantly, but also other countries are significant sources of information.

<<FIGURE 10>>

From previous discussions, the expectation is that technology flow among CJK countries would be most active in "electronic circuits and telecommunication technologies" since this is the technological field in which all three countries have strength.[16] In fact, this argument is confirmed by looking at citations broken down by

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[16] Peri (2005) finds that among many technology fields, technology flow is most active and has the farthest reach in technologies associated with the computer industry.

the nationality of citing patents and technology class. In addition, “electronic components and semiconductors”, “measurement, optics, and photography”, “display, sound, information memory”, and “clock, controlling, calculator” are found to be other important technology fields where these three countries are actively developing new technologies based on technologies developed elsewhere in CJK.

To demonstrate these findings more clearly, Figure 11 shows the shares of Chinese and Korean patents cited by Japanese patents in these five technology fields. These shares are small, but the trend is increasing over time. Figure 12 presents the similar pattern of China. For China, the trend is similar and now increasingly Chinese patents are based on patents granted to Japanese and Korean residents. Finally, Figure 13 shows the case for Korea. For Korea, patents granted to Chinese and Japanese residents are a significant source of technologies, accounting for about 10%.

<<FIGURE 11,12, 13>>

The citation lag is another window through which we can judge the technological development. We define the citation lag as the difference between the application year of the citing patent and the cited patent. The assumption is that the shorter the citation lag is, the more technological capability that citing country has. It also could mean that a country is paying closer attention to technological development in other countries. Looking at the data, the overall trend in citation lag is increasing. On average, it is 6 .4 years, but compared to the past, the lag is increasing.

Figure 14 shows the citation lag within CJK countries. The overall trend is that the lag is increasing over time for all three countries. The lag associated with Japanese patents citing Chinese and Korean patents are shorter than average lags for China and Korea, again suggestive of more mature technological capabilities in Japan. The lag associated with Korea and China are becoming similar in the recent years. These trends support the general trends explored in this paper. Overall, technological development is becoming harder because technology is becoming more complex. This shows the lengthening of the citation lag, which signifies the gestation period. Furthermore, the general ranking of technological capability follows Japan, Korea, and China, although the difference in their capabilities seems to be narrowing.

<<FIGURE 14>>

5. Concluding Remarks

From the illustrative analyses above, it is clear that technological development in CJK countries is becoming similar. At this point, Japan is the leading technology provider in the region, followed by Korea and China in that order. However, technological developments in China and Korea are occurring at a rapid clip. Clearly, China is still in the early development phase in terms of technological capabilities, although it is catching up with Japan and Korea at an astonishing pace.

Because of the similarity in the technological activities of CJK countries in electronics and precision instrument industry broadly defined, technology flows among these three countries are also strongest in electronics, telecommunications technologies, semiconductors, and precision instruments. What is perplexing is that average lag to citations are increasing no matter how it was measured. A priori, one would expect the citation lag to be shorter in recent years as long as accumulation of technological capabilities outstrips that of technological advancement. Therefore, one possible reason is that it is becoming harder to innovate in these fields because accumulation of prior knowledge is substantial and technology itself is becoming more complex. Increasingly, firms are now adopting more “open” approach to innovation. That is, collaboration with other entities such as universities, public research institutes, and other firms are now becoming essential to innovate because of the increase in complexity and cost of innovation.

CJK countries are now well-endowed with basic ingredients that are needed for innovation such as ample supply of human capital, adequate research capabilities of universities and public research institutes, and existence of large firms that are focusing on innovation. From the analysis above, technology flow in a handful of areas is quite active. To broaden the scope of technology flow among CJK would require supports from governments. If left it to pure market force, the technology flow would be limited to those in electronics and telecommunications fields. To the extent that better flow of technology is related to stronger innovation capabilities, stimulating technology flow in other areas may be fruitful.

In order to do so, we first need to ensure that intellectual property rights are well protected. The enforcement of IPR should be consistent among these countries so as to reduce risks for collaborative and open innovation environment. Second, CJK countries can collaborate more closely in developing and creating common regulations and standards together, especially in emerging fields where such regulations and standards are not well established yet. This kind of collaborative work on regulations and standards can bring two benefits. One is to foster closer research collaboration among CJK countries. Already such work is undertaken informally through Northeast Asia Standards Cooperation Forum, which started its operation in 2002. Through discussions among three countries, they have achieved some success in harmonizing existing standards and crafting new common standards where such standards were missing in CJK countries. One such success was the establishment of common standards on accessibility design. This kind of standards was not in place in China and Korea. After considerable discussion, China, Japan, and Korea agreed to adopt the standard based on JIS, and also to submit to ISO to make this as an international standard.

Currently topics under discussion by the Forum are based on proposals that were made by each country. This approach is workable, but quite ad hoc in identifying the promising areas for collaboration. In order to facilitate more systematic approach, we should create the database that contains information on the compatibility between standards of China, Japan, and Korea, and to ISO. In addition, further research should be conducted to analyze the impact of common standards on innovation and economic activities. Secondly such common regulations and standards would enable CJK countries to take a lead in international standard setting, which would ensure technology and industrial capabilities developed in CJK can be widely utilized in global market. It is desirable to support firms, especially to SMEs, to participate in this kind of forum and also to attend international standard setting workshops, which would eventually raise the awareness of international standards among SMEs.

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Table 1. Description of Patent Database

Source	Variable	No. of obs.
Patent registration	Application ID, Registration ID, Registration date, Assignee name, Assignee country, Inventor country, Claim number, Technology classification	3,693,144
Patent citation	Citing patent registration ID, Cited patent registration ID, Citation type	39,997,261

Table 2. Top 10 Patenting Country

Year Ranking	1976	1980	1990	2000	2009
1	**Japan**	**Japan**	**Japan**	**Japan**	**Japan**
	(29.83)	(34.51)	(52.24)	(48.84)	(44.87)
2	Germany	Germany	Germany	Germany	**Korea**
	(25.63)	(24.85)	(18.09)	(14.13)	(11.20)
3	U.K.	U.K.	France	France	Germany
	(11.17)	(9.32)	(6.53)	(5.33)	(10.41)
4	France	France	U.K.	**Korea**	**Taiwan**
	(9.37)	(8.91)	(5.65)	(5.01)	(7.74)
5	Switzerland	Switzerland	Switzerland	**Taiwan**	France
	(5.41)	(5.26)	(2.84)	(4.84)	(3.55)
6	Sweden	Sweden	Canada	U.K.	Canada
	(3.49)	(3.01)	(2.74)	(3.55)	(3.09)
7	Canada	Canada	Italy	Canada	Netherlands
	(3.19)	(2.85)	(2.72)	(3.54)	(2.67)
8	Italy	Italy	Sweden	Sweden	U.K.
	(2.51)	(2.84)	(1.56)	(2.38)	(2.21)
9	Netherlands	Netherlands	Netherlands	Switzerland	Switzerland
	(1.64)	(1.43)	(1.43)	(2.20)	(1.96)
10	Belgium	Belgium	Finland	Italy	Sweden
	(1.20)	(0.86)	(0.76)	(2.04)	(1.49)

Note: Parentheses are the percentage of patent applied by country in total patent applications

Table 3. Number of Patents Granted Across Technology Classification

Number	Title	Japan	Korea	China
1	Agriculture	2255	86	23
2	Food stuffs	2466	130	6
3	Personal and domestic articles	4763	681	93
4	Health and amusement	14,350	422	86
5	Drugs	9311	441	119
6	Separating, mixing	16,396	1,041	151
7	Machine tools, metal working	14,669	466	60
8	Casting, grinding, layered product	25,202	733	69
9	Printing	20,067	748	30
10	Transporting	26,322	886	50
11	Packing, lifting	12,880	588	43
12	Non-organic chemistry, fertilizer	8,451	396	39
13	Organic chemistry, pesticides	19,984	966	179
14	Organic molecule compounds	20,055	789	73
15	Dyes, petroleum	7,482	342	46
16	Biotechnology, beer, fermentation	4,905	298	53
17	Genetic engineering	498	66	13
18	Metallurgy, coating metals	12,196	653	23
19	Textile	5,887	577	17
20	Paper	797	13	3
21	Construction	4,057	317	38
22	Mining, drilling	338	8	15
23	Engine, pump	26,941	880	26
24	Engineering elements	19,219	763	51
25	Lighting, steam generation, heating	9,951	1,753	81
26	Weapons, blasting	337	30	8
27	Measurement, optics, photography	110,566	7,774	241
28	Clock, controlling, computer	62,754	4,548	178
29	Display, information storage, instruments	56,259	9,071	112
30	Nuclear physics	1,650	77	4
31	Electronics components, semiconductor	113,756	17,083	501
32	Electronics circuit, communication tech.	68,627	11,027	322
33	Others	22	6	0

Note: Patents are granted to applicants who reside in Japan, Korea, or China since 1976.

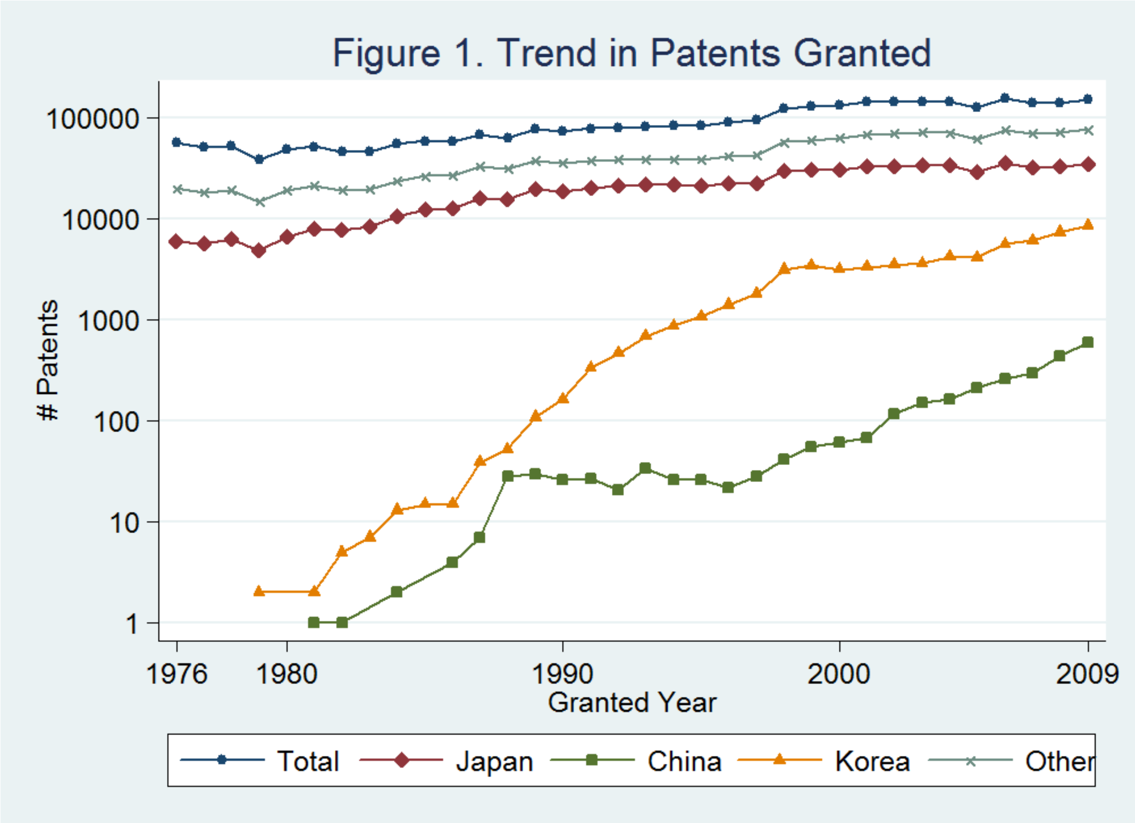


Figure 1. Trend in Patents Granted
100000
10000
1000
100
10
1
Patents
1976
1980
1990
2000
2009
Granted Year
Total
Japan
China
Korea
Other

Figure 2. Technology Specialization for Japanese Patents

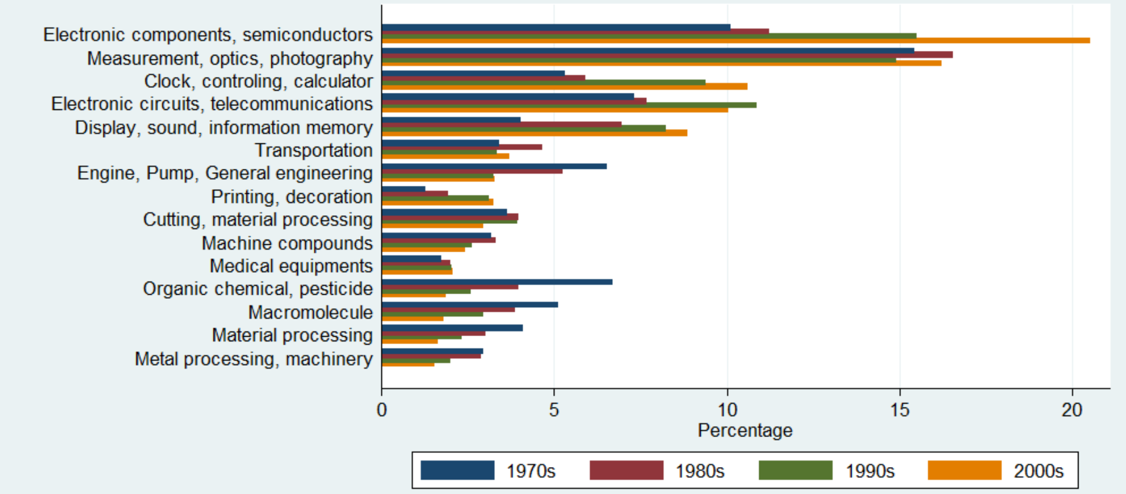


Figure 3. Technology Specialization for Chinese Patents

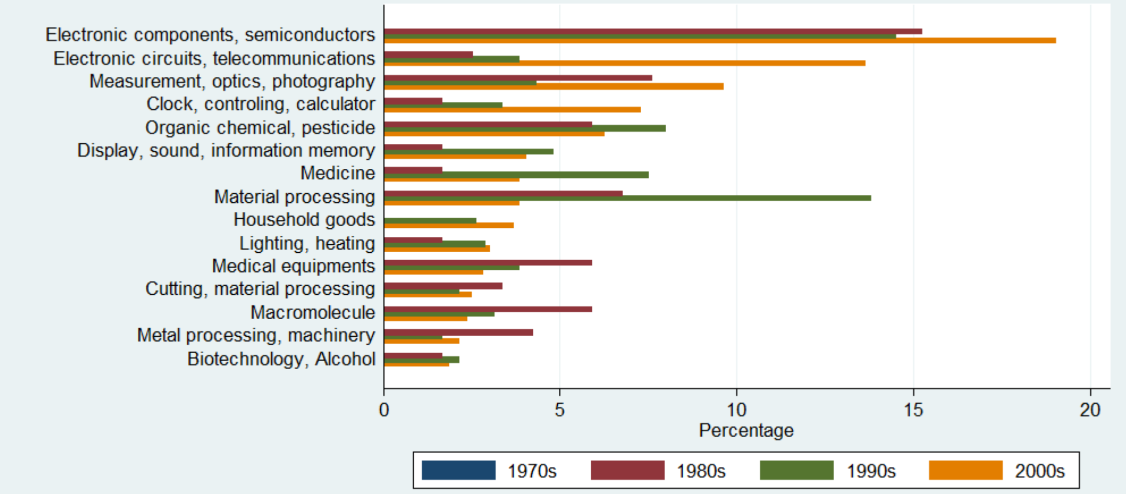


Figure 4. Technology Specialization for Korean Patents

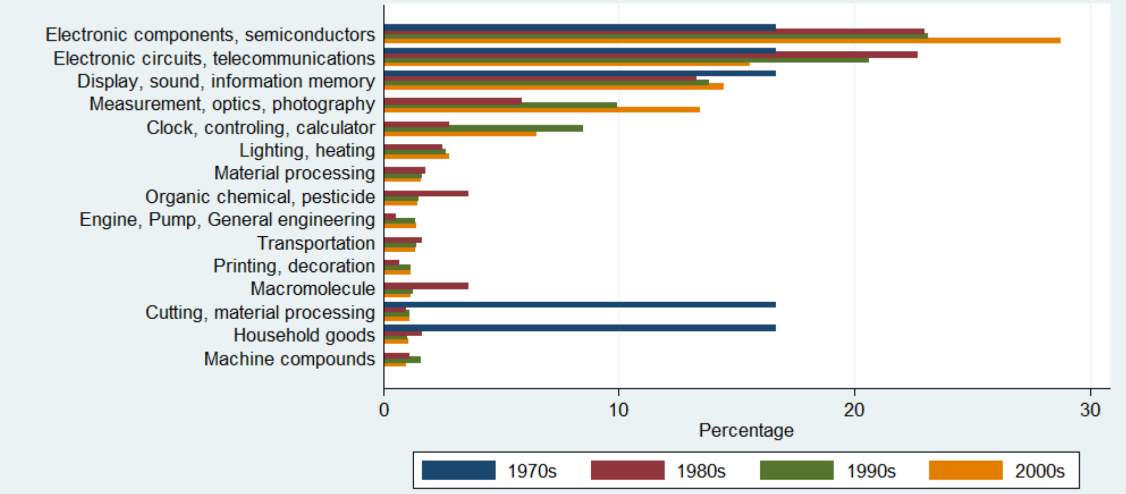


Figure 5. Average Patent Citations

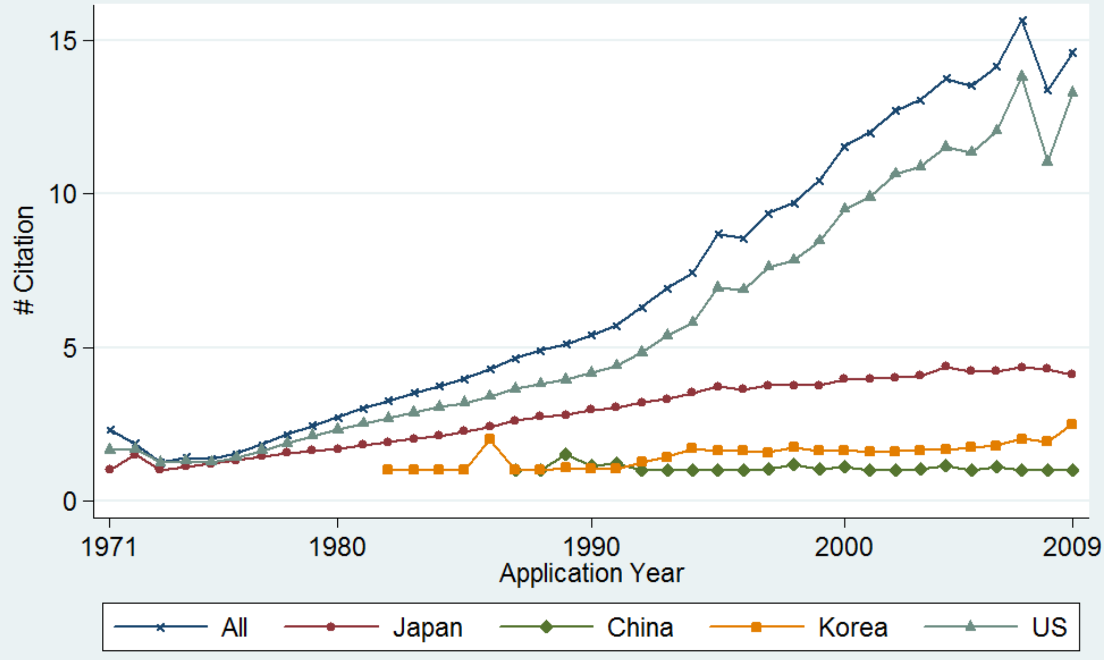
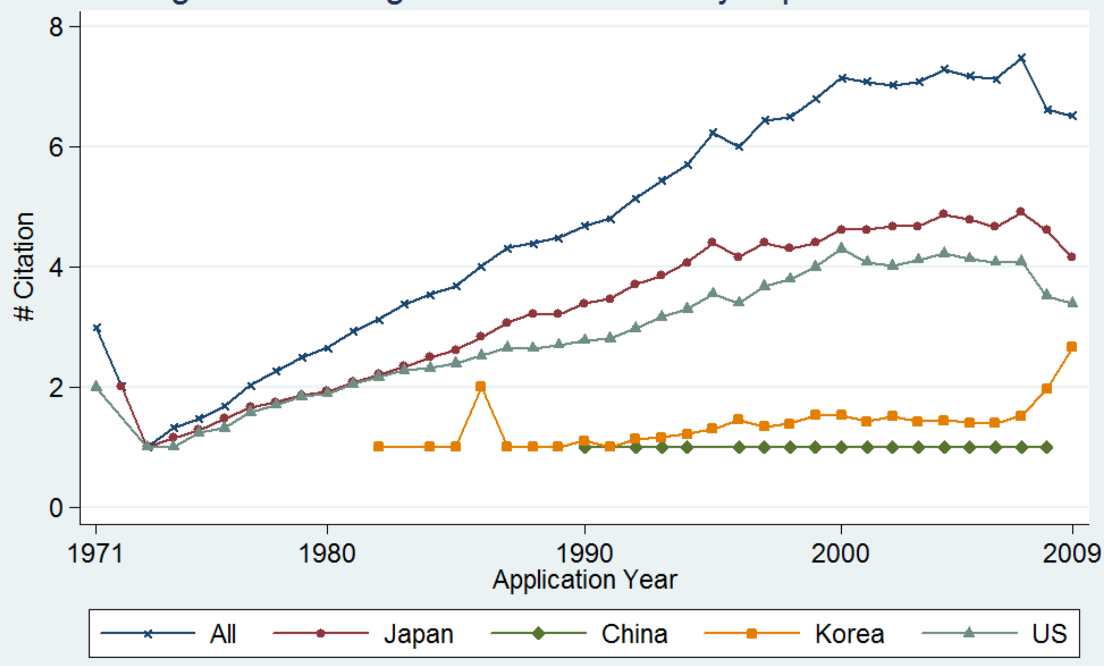


Figure 6. Average Patent Citations by Japanese Patents



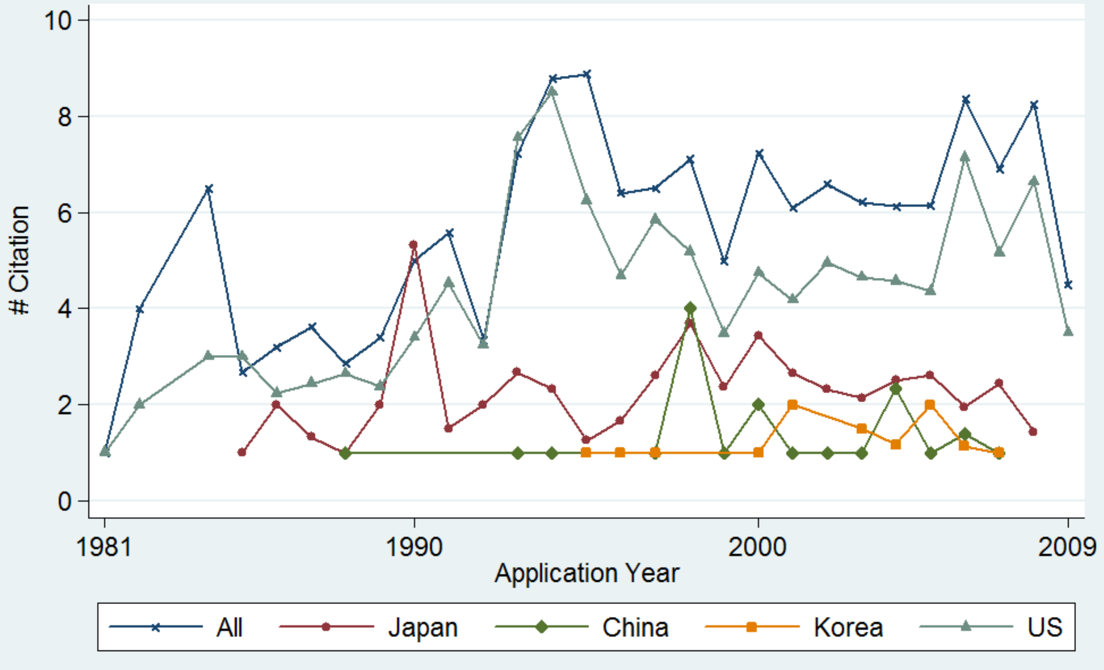


Figure 7. Average Patent Citations by Chinese Patents

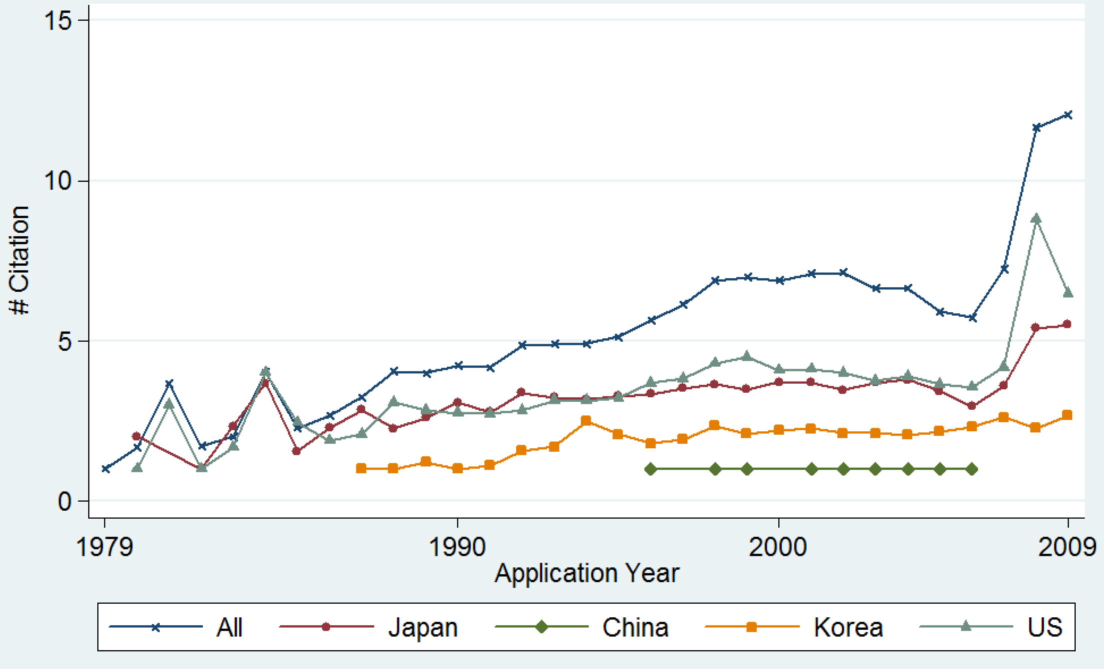


Figure 8. Average Patent Citations by Korean Patents

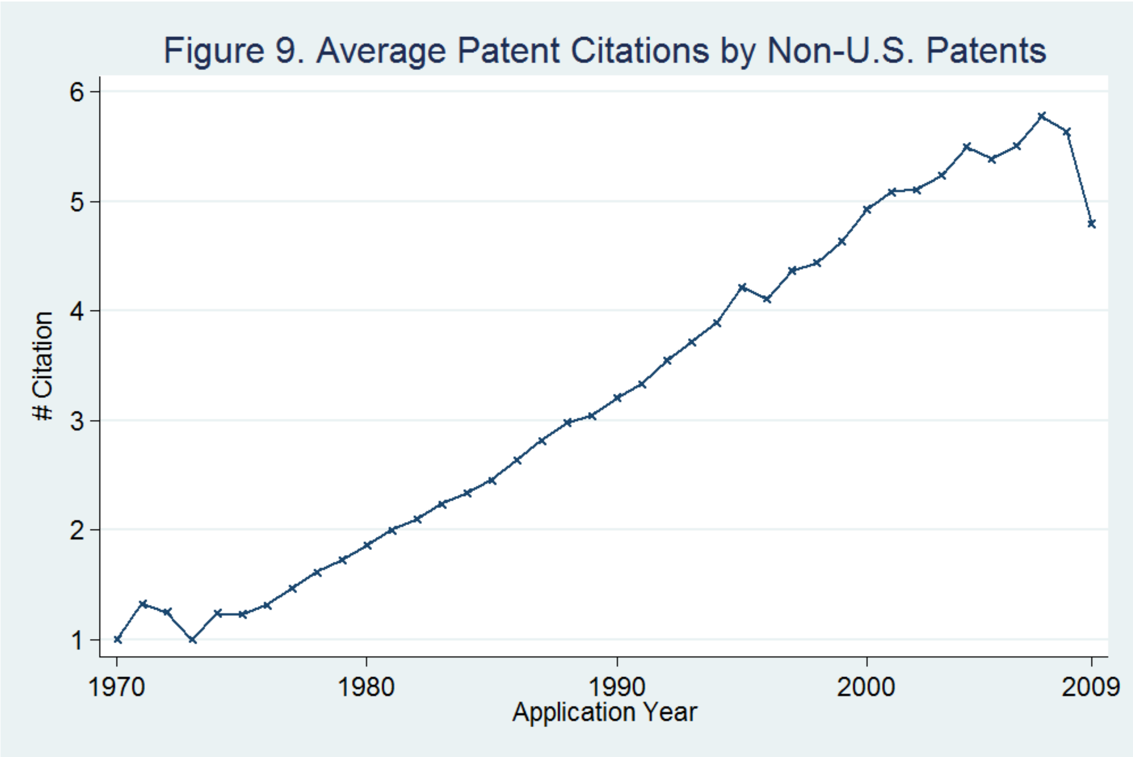


Figure 9. Average Patent Citations by Non-U.S. Patents
Citation
1
2
3
4
5
6
1970
1980
1990
2000
2009
Application Year

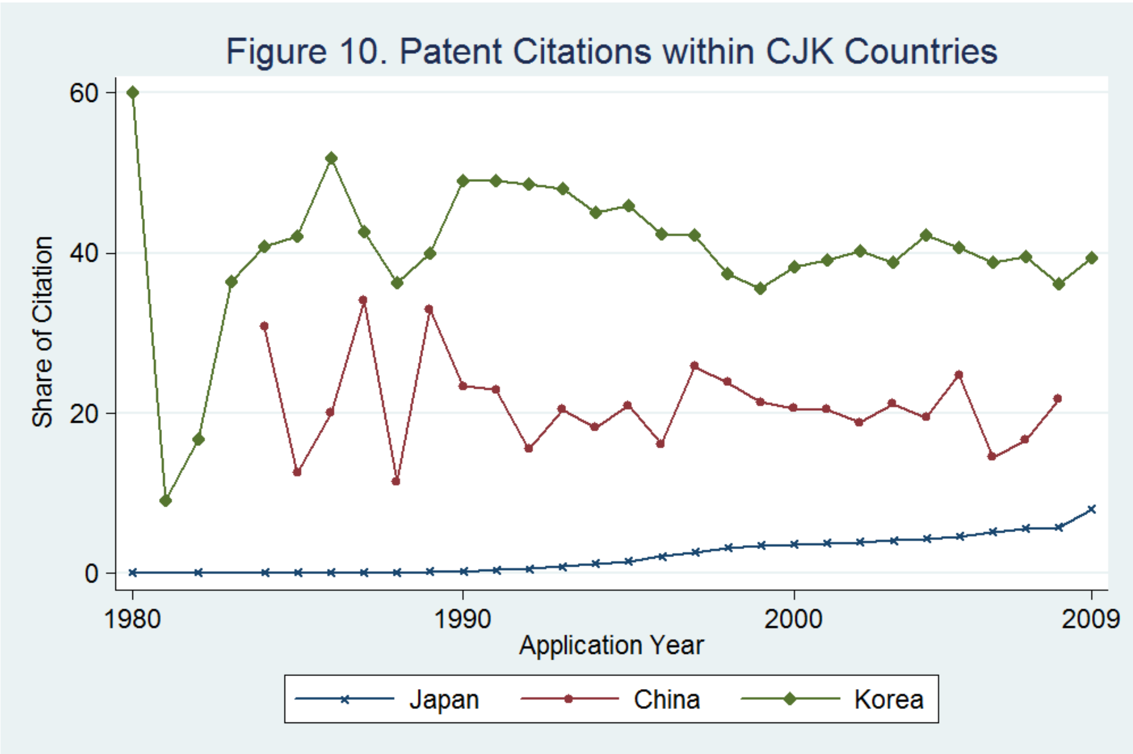


Figure 10. Patent Citations within CJK Countries
Share of Citation
0
20
40
60
1980
1990
2000
2009
Application Year
Japan
China
Korea

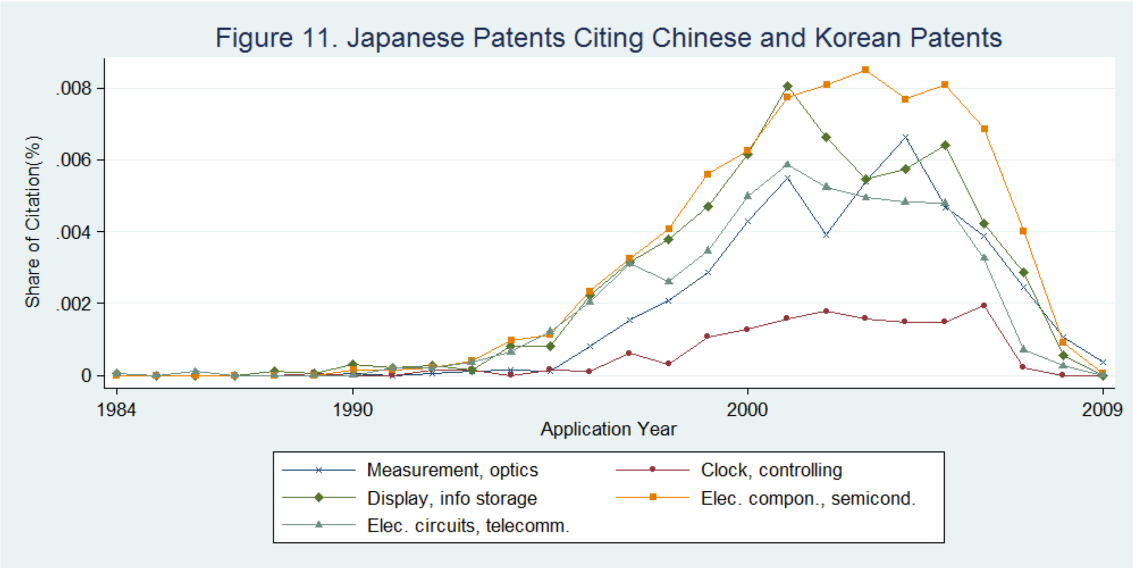


Figure 11. Japanese Patents Citing Chinese and Korean Patents
Share of Citation(%)
.008
.006
.004
.002
0
1984
1990
2000
2009
Application Year
Measurement, optics
Display, info storage
Elec. circuits, telecomm.
Clock, controlling
Elec. compon., semicond.

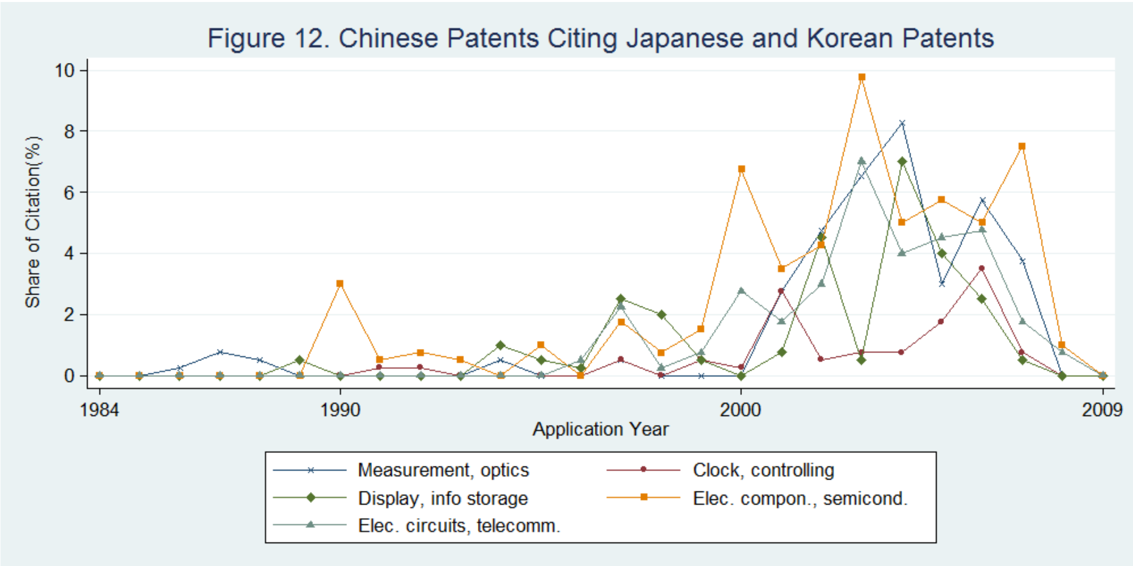


Figure 12. Chinese Patents Citing Japanese and Korean Patents
Share of Citation(%)
10
8
6
4
2
0
1984
1990
2000
2009
Application Year
Measurement, optics
Display, info storage
Elec. circuits, telecomm.
Clock, controlling
Elec. compon., semicond.

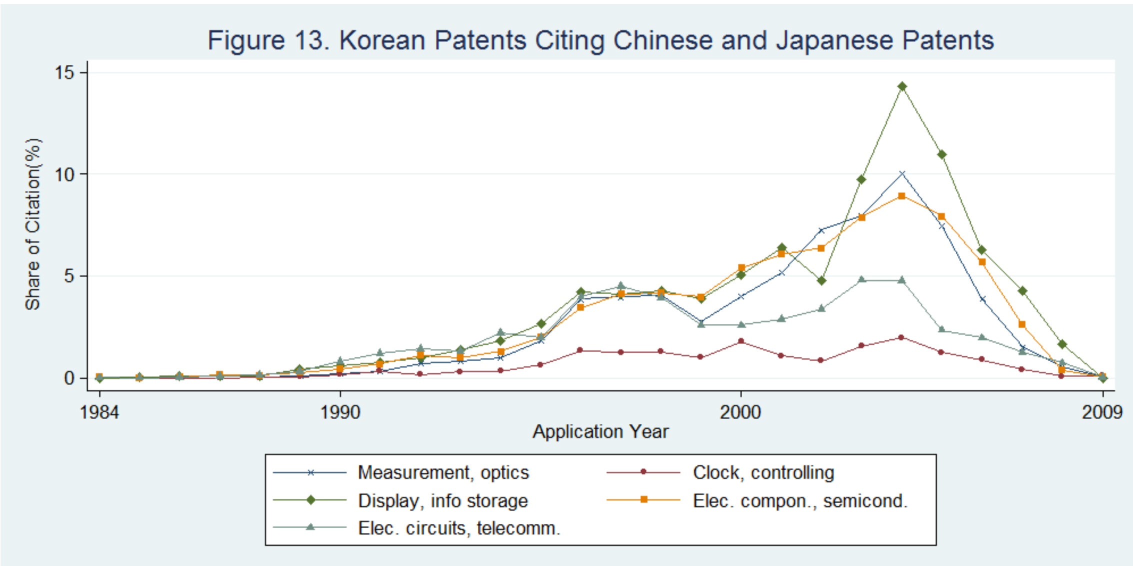


Figure 13. Korean Patents Citing Chinese and Japanese Patents
Share of Citation(%)
15
10
5
0
1984
1990
2000
2009
Application Year
Measurement, optics
Display, info storage
Elec. circuits, telecomm.
Clock, controlling
Elec. compon., semicond.

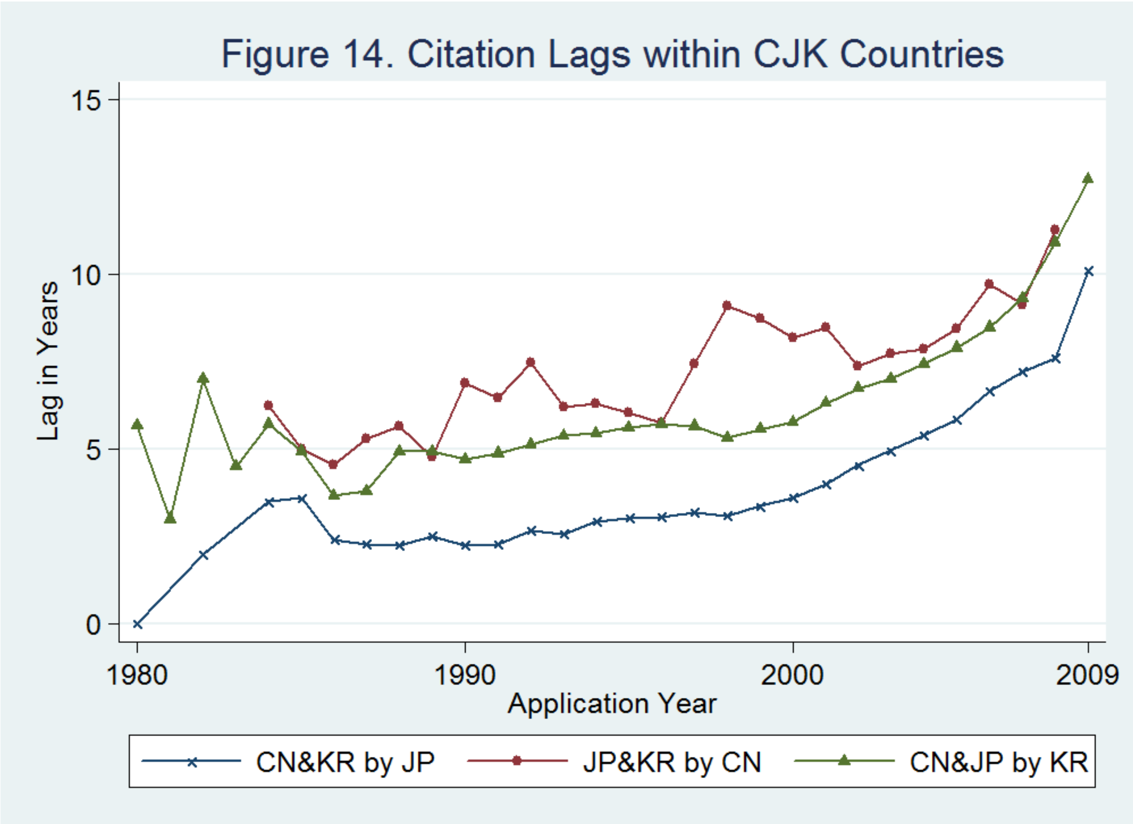


Figure 14. Citation Lags within CJK Countries
Lag in Years
15
10
5
0
1980
1990
2000
2009
Application Year
CN&KR by JP
JP&KR by CN
CN&JP by KR