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Innovation Networks in China, Japan, and Korea: Evidence from Japanese Patent Data

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March 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 Japanese patent data, we examine how knowledge networks have developed among these countries. We find that Japan's technological specialization saw little change, 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". Patent citations suggest that technology flows were largest in the electronic technology, pointing to the deepening of innovation networks in these countries.

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

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Innovation Networks among China, Japan, and Korea: Evidence from Japanese Patent Data*

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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 Japanese patent data, we examine how knowledge networks have developed among these countries. We find that Japan's technological specialization saw little change, 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". Patent citations suggest that technology flows were largest in the electronic technology, pointing to the deepening of innovation networks in these countries.

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1. Introduction

As technological innovation has become the main driver of economic growth in recent decades, many countries have focused on nurturing innovation capabilities as a component of growth strategies.[1] To foster domestic innovation capability, national governments have traditionally implemented a variety of science and technology policies, including public investment in education, direct subsidies for research, and institutional protection of innovation. The development of innovation capability at home remains to be a crucial area for public policies.

However, the changing process of innovation has strongly influenced the way in which we attempt to promote innovative activity. 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 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 current innovation is complex in technology and straddles 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). Firms need to catch up with ongoing innovations abroad to build technological competitiveness based upon the frontier technology.

In this paper, we use Japanese patent data to examine how knowledge networks have developed among China, Japan, and Korea for 1966-2009. Many economies in East Asia are keen on developing technological capabilities and attempt to shift its economy to more knowledge-based economy.[2] Within East Asia, three countries – China, Japan, and Korea (hereafter, CJK countries) are most important in terms of technological capabilities. Japan and Korea are now technological leaders in Northeast Asia while China is very rapidly catching up on the technology ladder. CJK countries not only play a major role in Northeast Asia but also become the engine of the global

[1] For instance, see Yusuf and Nabeshima (2010) on the need to develop technological capabilities to sustain rapid growth in Southeast Asia region.

[2] 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.

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. In this respect, it is crucial to shed light on the formation of innovation networks among the CJK countries.

However, a quantitative assessment of innovation networks is a challenging task mainly for the intangible nature of knowledge flows and inventive activities. Cross-border technology networks would affect an underlying rate of scientific and technological progress, but 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. The grant is determined according to the novelty and potential usefulness of the invention. Griliches (1990) is one of the pioneers to use patent statistics for economic analysis, who argues that patent statistics are good indicators of successful inventive activity. Furthermore, a patent contains citation information that represents the identity and content of existing knowledge used to produce the invention. As the U.S. patent data are widely used for research (Hall, Jaffe and Trajtenberg 2001), the patent citation allows us to quantitatively examine a linkage between patented innovations.

Our analysis provides the following findings on technology specialization and knowledge networks among the CJK countries, as measured by Japanese patent data. First, Japan’s technological specialization saw little change, 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”. Second, this convergence in specialization suggests that technology flow among these three countries would be largest in the electronic technology. An analysis of patent citations confirms such implications; the most active field of patent citation occurred in the electronic technology. In addition, “electronic components and semiconductors” are found to be another important technology field.

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

The Japanese patent database comes from the Japanese Patent Office.[3] It contains the bibliographic information on all patents applied for at the Japanese Patent Office during 1964-2009. The database contains five tables: patent application table; patent registration table; applicant table; rights holder table; and citation information table. Table 1 indicates the number of sample observations and available variables included in each table.

<<TABLE 1 >>

Our main interest lies in the citation data, which we use as the measure for technology flow among China, Japan, and Korea. In assigning the “nationality” of a patent, one has to determine whether the “nationality” or the “residence” is the focus of the research. The “nationality” is the registered nationality of either applicants or inventors. This is a useful proxy to indicate where invention is made when nationality and country are identical for that invention. However, it does not tell us exactly where the invention occurred. Rather, it merely suggests where the applicants or inventors belong to. Therefore, we use “residence” as the nationality of a patent since our interest lies more on the geographical location where invention occurred. However, the database does not contain “nationality” variable based on location. We parsed the address field and assigned ISO two-character country codes to each patent. In this study, we are also primarily interested in the innovation activities of firms. Thus, we assigned “nationality” based on applicants rather than inventors. Because some of the records did

[3] See Goto and Motohashi (2007) for the description of older versions of these tables.

not have address data, excluding these samples reduced the dataset to around 3.5 million 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 Japanese Patent Office, which are further broken down by the nationality. The number of patents granted steadily increased from 3,268 in 1966 to 146,240 in 2009. In 2009, 86% of patents were registered to Japanese national and the rest to foreign applicants. Of the foreign applicants, Korea’s share is a 9% and China’s 0.5%.

<<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 1970, among the foreign applicants, those from the U.S. accounted for more than half of patents granted to foreign residents, followed by Germany, and UK. All of the top 10 foreign applicants were from OECD countries. The situation did not change much in 1980 and 1990, except for the entry of Soviet Union. By 2000, however, the situation has changed dramatically. Korea first appeared in the top 10 in 1994. Since then, the number of patents granted to Korean residents increased steadily and Korea ranked the third among foreign applicants along with Taiwan at the 10^{th}. After 2000, the country ranking has remained almost unchanged. During this period, China has never been ranked in the top 10.

<<TABLE 2>>

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. We count the total number of patents granted to applicants who resided in China, Japan, or Korea since 1966. 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 "electronics components, semiconductors" followed by "measurement, optics, and photography" [4]. In 1980s, technological specialization by Japan did not change much from 1970s, still featuring "electronics components, semiconductors" and "measurement, optics, and photography" as the most active patenting field. The technological specialization of Japan in 1990s and 2000s saw little change, but an exception in 2000s is a slight increase in shares for "electronics circuit, and communication technologies."

<<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 Japanese Patent Office. In 1980s, however, the patents granted by Chinese residents belonged to the technology class in "health and amusement" and "clock, controlling, and computer". These technological fields were the two most active during the period. In 1990s, China's specialization has shifted to "separating and mixing", which is related more to processing technologies. Finally, China's specialization in 2000s was active in "electronic circuits and communication technologies". Relative to other field, this is the strongest technological field of China, which by itself accounted for one-fifth of patents granted to Chinese residents.

<<FIGURE 3 >>

We turn to examine the technology specialization for Korean residents in Figure 4. In 1970s, Korea excelled in "lighting, steam generation, and heating" and "organic

[4] 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.

chemistry, pesticides". By contrast to Japan and China, Korea has seen a dramatic shift in its technological specialization in 1980s as compared to those in 1970s. In 1970s, there was no patents granted to Korean resident in the field of "electronics components, semiconductors", but this has suddenly emerged as the leading field of technology in 1980s.[5] This is followed by "display, information storage, and instruments" and "electronics circuits and communication technologies". Together, these three technology field account for 47% of patents granted to Korean resident. From such a change, it is quite apparent that the industrial development in electronics, telecommunication equipment, and information technologies has progressed in Korea at a rapid pace.

<<FIGURE 3 >>

In the 1990s, Korea's patent fields were the same as in 1980s, "electronics components, semiconductors" followed by "display, information storage, and instruments" and "electronics circuits and communication technologies". However, the share of these three fields together increased steadily during the period, which accounted for 57%. It seems that patents granted to Korean residents were concentrated more on these three fields relative to the others. Furthermore, technological specialization in Korea started to change in 2000s. While "electronics components, semiconductors" were still at the top, the second spot became "electronics circuits and communication technologies", followed by "measurement, optics, and photography" and "display, information storage, and instruments". These four fields accounted for close to 60% of patents granted to Korean resident, suggesting the expansion of Korea's technological capabilities in the recent decade.

<<FIGURE 4 >>

[5] 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).

An examination of technology specialization demonstrates that technology specialization has become quite similar among these countries. Japan's technological specialization did not see change from 1970s up until 2000s, but Korea's specialized fields have changed dramatically since 1980s, which seems to be still evolving. While Korea did not have any patent in electronics or telecommunication fields in 1970s, Korea started to receive patents in these areas in 1980s. Since then, Korea has focused its efforts in electronics, semiconductors, and telecommunication equipment. As a result, Korea's technology specialization mirrors that of Japan.[6]

Similar to the technological development of Korea, China also saw changing technological capabilities. Its strength shifted over time, which gradually focused on "electronic circuits and telecommunication technologies". This field of technology appears to converge to the technological specialization n Japan and Korea. While China's technological capability was still narrowly focused on this one field, the expectation is that China will broaden her capabilities to other fields in future. 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, especially in "electronic circuits and telecommunication technologies".

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 is 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 6.7 million citing-cited pair observations.[7] Figure 5 shows the trend in average citations per patent since 1965, with the application year used as the indicator for time. In the past, the average citation was just one. However, the number of citation was increasing in the recent years. On average, a patent cites four 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.

[6] The specialization pattern of patents granted to Korean residents is more apparent than that of Japan. There are two possible reasons for this. One is that for Korean residents, it is more expensive to obtain patents in Japan. Hence, only the valuable patents would be registered in Japan. Secondly, this actually reflects the technological capabilities of Korea as a whole. To test for the latter, more data is needed.

[7] Each patent can cite multiple patents ("prior art").

<<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 US resident for illustration. From the figure, it is apparent that the citations made to Japanese patents follow the general trend. With a considerable lag, a similar trend can be seen for patents granted to Korean residents. Until 1994, Korean patents on average cited only once, but the citation frequency is increasing in the latter year. 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. Japanese patents also cite US patents often, but the frequency of citing US patents and Korean patents are now on par, 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 for small samples, it indicates that the Chinese patents also predominantly cite Japanese patents, which seldom cite patents registered to residents in China, Korea, and the U.S. Finally, Figure 8 shows that Korean patents also predominantly cite Japanese patents, but Korean patents also cite other Korean patents more often as compared to patents registered to other countries. In fact, Korean patents cite more Korean patents than US patents since 1998. Korean patents hardly cite any Chinese patents.

<<FIGURE 6, 7, 8>>

Figure 9 shows the trend in citations that are made to non-Japanese patents since 1970. Similar to the overall trend, the citations made to non-Japanese 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. For Chinese and Korean patents, the share of citations made to CJK countries (excluding citations to own country) is a significant portion. 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 the other country is a significant source 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.[8] In fact, this argument is confirmed by looking at citations broken down by the nationality of citing patents and technology class. In addition, "electronic components and semiconductors" is found to be another important technology field where these

[8] 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.

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 “electronic circuits and telecommunication technologies” and “electronic components and semiconductors”. These shares are small, but the trend is increasing over time. Figure 12 presents the similar pattern of China. For China, in some years, close to half of technologies 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.

<<FIGURE 11,12, 13>>

Another way to judge the technological development is to look at the citation lag. 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 lag associated with Japanese patents citing Chinese patents are lower than the overall average at 4.9 years, but the trend is increasing. Similarly, the average lag to citation made to Korean patents is increasing, although the lag on average is only 3.5 years. This means that Japanese patents are integrating technologies developed in Korea at much faster pace than those in China.

Next, the lag associated with Chinese patents citing Japanese patents are on average longer than the overall average at 8.6 years. The trend is also such that the average citation lag is getting longer in time. There were too few citations to Korean patents by Chinese patents in our data. Finally, the lag associated with Korean patents citing Japanese patents follow a U-shape. It was decreasing in the past, but since 1997, it is increasing. The average citation lag is 7.1 years, lower than citation lag associated with Chinese patents, but longer than those of Japanese patents. Also, there were too few citations to Chinese patents by Korean patents in our data.

<<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 the speed in which it is catching up with Japan and Korea is astonishing.

Because of the similarity in the technological activities of CJK countries in electronics industry broadly defined, technology flows among these three countries are also strongest in electronics, telecommunications technologies and semiconductors. 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 certain 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 closer research collaboration among CJK countries. 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.

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Table 1. Description of Patent Database

Source	Variable	No. of obs.
Patent application	Application ID, Application date, Examination date, Claim number, Technology classification	11,254,825
Patent registration	Application ID, Registration ID, Registration date, Termination date, Claim number, Technology classification	3,507,336
Applicants	Applicant ID, Applicant name, Applicant address	1,006,572
Patent rights holders	Right holder ID, Right holder name, Right holder address	8,437,721
Patent citation	Citing patent registration ID, Cited patent registration ID, Citation type	13,771,216

Table 2. Top 10 Patenting Country

Year Ranking	1970	1980	1990	2000	2009
1	United States	United States	United States	United States	United States
	(51.18)	(57.61)	(45.53)	(46.4)	(39.04)
2	Germany	Germany	Germany	Germany	Germany
	(15.49)	(17.66)	(21.42)	(16.31)	(16.37)
3	United Kingdom	United Kingdom	France	**South Korea**	**South Korea**
	(10.03)	(5.59)	(7.70)	(8.82)	(9.29)
4	Switzerland	Switzerland	Switzerland	France	France
	(7.46)	(4.89)	(5.14)	(6.11)	(6.38)
5	France	Netherlands	United Kingdom	Netherlands	Netherlands
	(4.53)	(3.64)	(5.04)	(3.67)	(5.36)
6	Sweden	France	Netherlands	United Kingdom	Switzerland
	(2.16)	(2.44)	(3.76)	(3.54)	(4.70)
7	Italy	Soviet Union	Sweden	Switzerland	United Kingdom
	(1.39)	(2.09)	(2.37)	(3.51)	(3.46)
8	Netherlands	Sweden	Italy	Italy	Sweden
	(1.33)	(1.50)	(2.36)	(1.82)	(3.07)
9	Belgium	Italy	Soviet Union	Sweden	**Taiwan**
	(1.12)	(1.00)	(1.14)	(1.70)	(1.82)
10	Canada	Canada	Canada	**Taiwan**	Italy
	(1.04)	(0.90)	(0.88)	(1.39)	(1.59)

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	38,745	75	3
2	Food stuffs	37,847	130	7
3	Personal and domestic articles	45,140	328	17
4	Health and amusement	79,847	278	29
5	Drugs	21,564	164	24
6	Separating, mixing	79,881	224	28
7	Machine tools, metal working	110,925	167	7
8	Casting, grinding, layered product	115,041	169	7
9	Printing	62,052	198	4
10	Transporting	107,507	315	9
11	Packing, lifting	103,406	212	5
12	Non-organic chemistry, fertilizer	72,232	264	20
13	Organic chemistry, pesticides	82,978	476	22
14	Organic molecule compounds	97,345	430	16
15	Dyes, petroleum	52,616	128	21
16	Biotechnology, beer, fermentation	19,488	113	6
17	Genetic engineering	2,550	88	2
18	Metallurgy, coating metals	88,208	229	8
19	Textile	63,239	347	4
20	Paper	8,885	15	1
21	Construction	125,281	208	7
22	Mining, drilling	13,987	15	1
23	Engine, pump	87,149	378	7
24	Engineering elements	70,414	233	11
25	Lighting, steam generation, heating	93,525	865	16
26	Weapons, blasting	2,885	3	1
27	Measurement, optics, photography	293,422	1611	21
28	Clock, controlling, computer	157,556	678	14
29	Display, information storage, instruments	127,297	2323	7
30	Nuclear physics	12,261	29	0
31	Electronics components, semiconductor	389,483	3932	21
32	Electronics circuit, communication tech.	221,520	3092	50
33	Others	239	17	3

Note: Patents are granted to applicants who reside in Japan, Korea, or China since 1966.

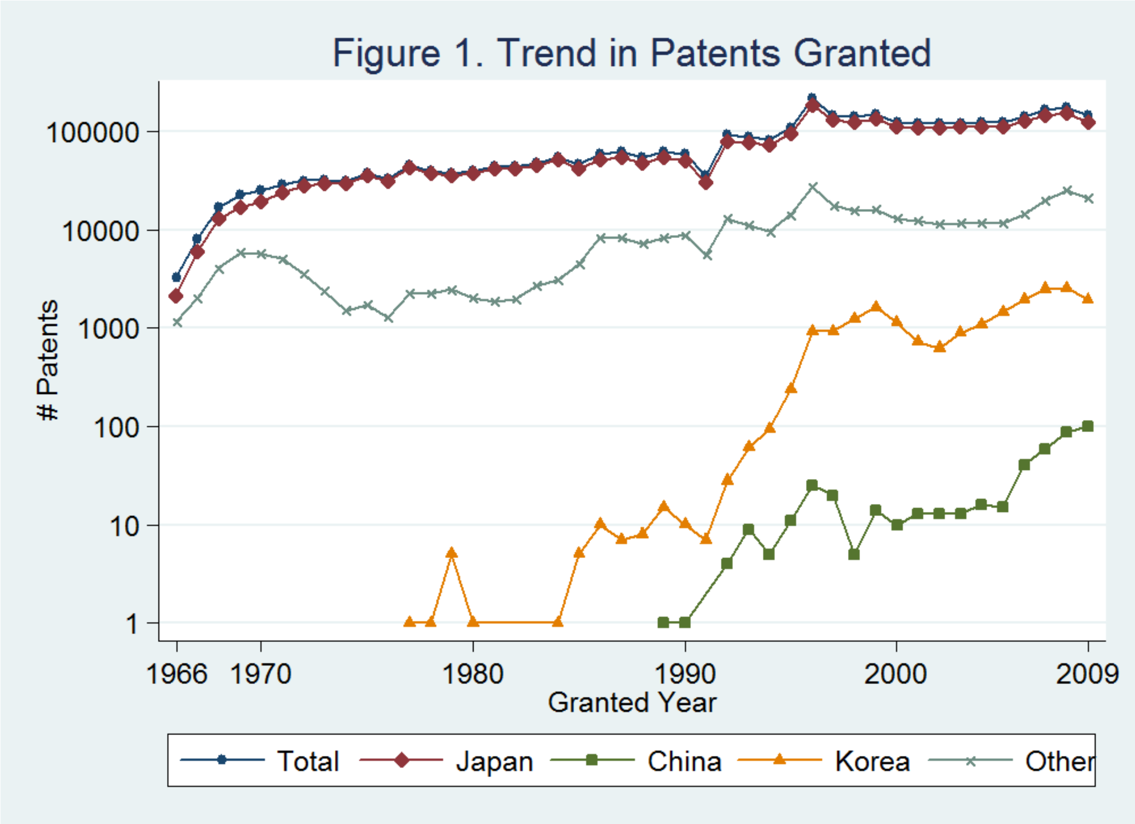


Figure 1. Trend in Patents Granted
Patents
100000
10000
1000
100
10
1
1966
1970
1980
1990
2000
2009
Granted Year
Total
Japan
China
Korea
Other

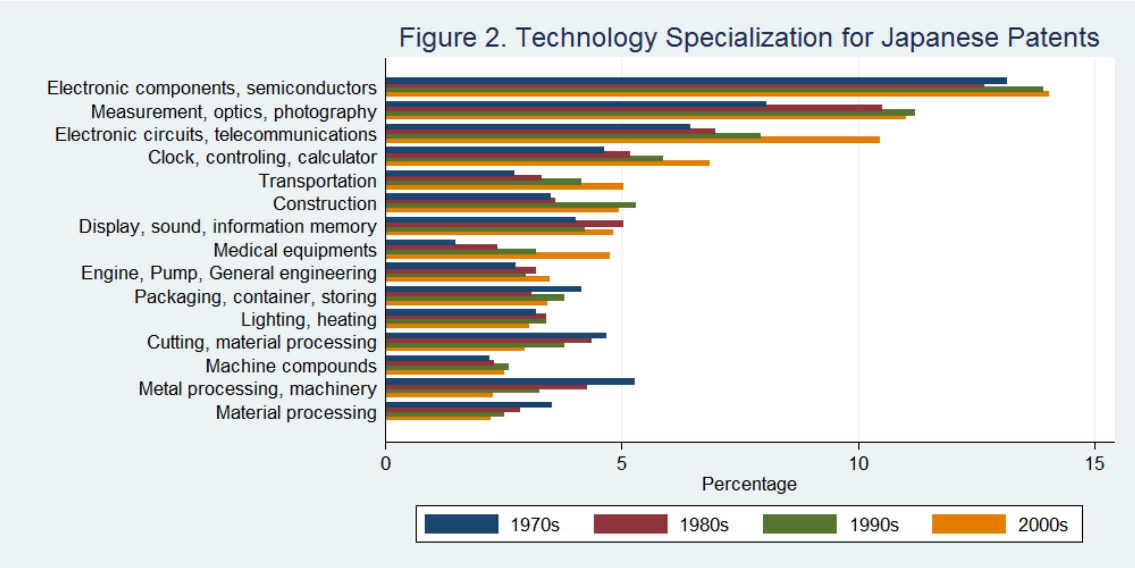


Figure 2. Technology Specialization for Japanese Patents
Electronic components, semiconductors
Measurement, optics, photography
Electronic circuits, telecommunications
Clock, controling, calculator
Transportation
Construction
Display, sound, information memory
Medical equipments
Engine, Pump, General engineering
Packaging, container, storing
Lighting, heating
Cutting, material processing
Machine compounds
Metal processing, machinery
Material processing
0
5
10
15
Percentage
1970s
1980s
1990s
2000s

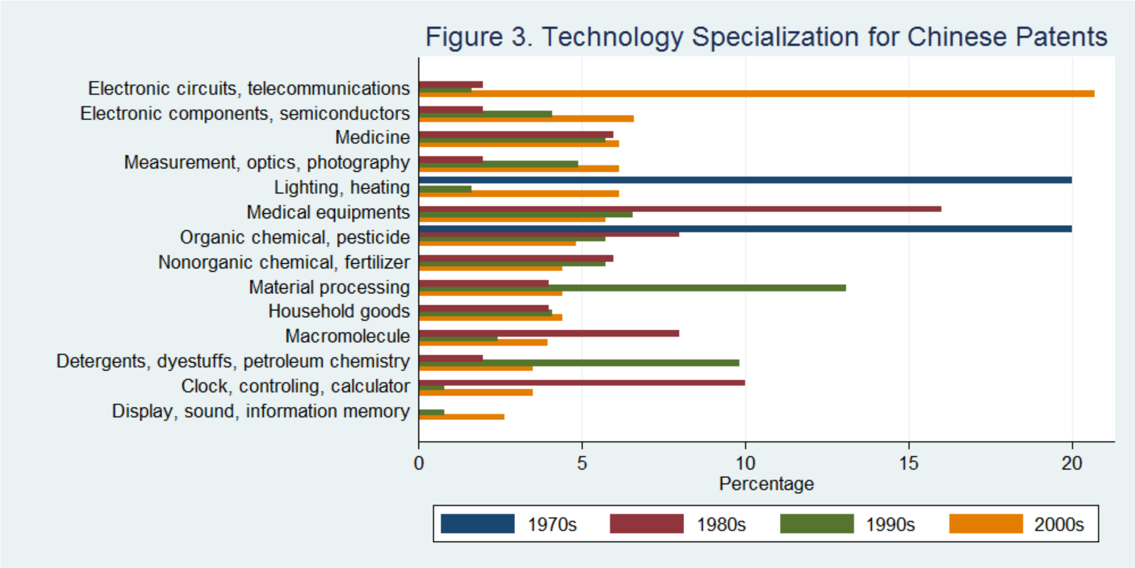


Figure 3. Technology Specialization for Chinese Patents
Electronic circuits, telecommunications
Electronic components, semiconductors
Medicine
Measurement, optics, photography
Lighting, heating
Medical equipments
Organic chemical, pesticide
Nonorganic chemical, fertilizer
Material processing
Household goods
Macromolecule
Detergents, dyestuffs, petroleum chemistry
Clock, controling, calculator
Display, sound, information memory
0
5
10
15
20
Percentage
1970s
1980s
1990s
2000s

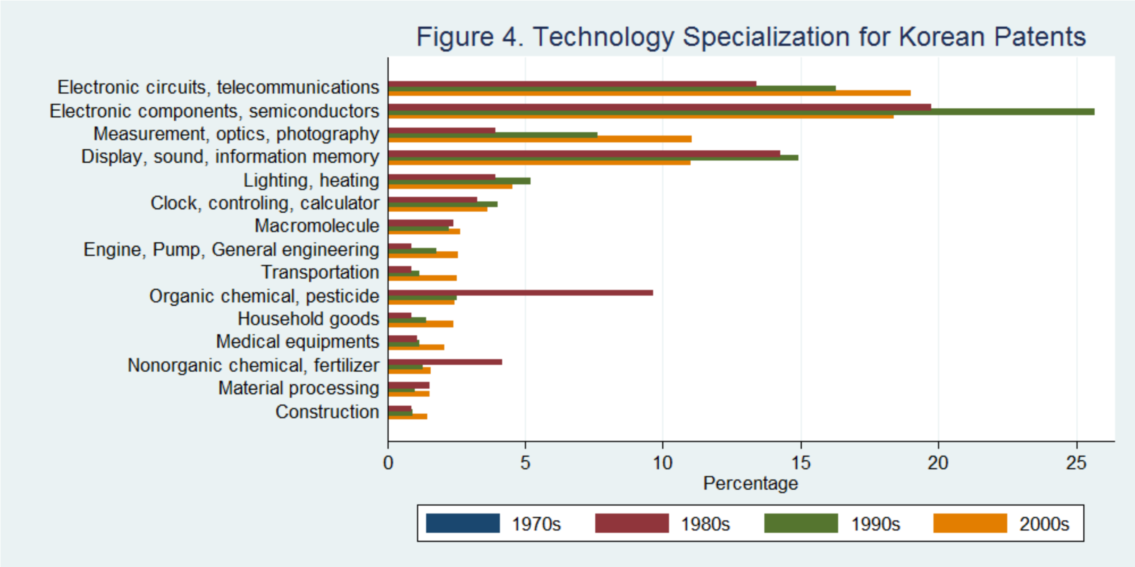


Figure 4. Technology Specialization for Korean Patents
Electronic circuits, telecommunications
Electronic components, semiconductors
Measurement, optics, photography
Display, sound, information memory
Lighting, heating
Clock, controling, calculator
Macromolecule
Engine, Pump, General engineering
Transportation
Organic chemical, pesticide
Household goods
Medical equipments
Nonorganic chemical, fertilizer
Material processing
Construction
0
5
10
15
20
25
Percentage
1970s
1980s
1990s
2000s

Figure 5. Average Patent Citations

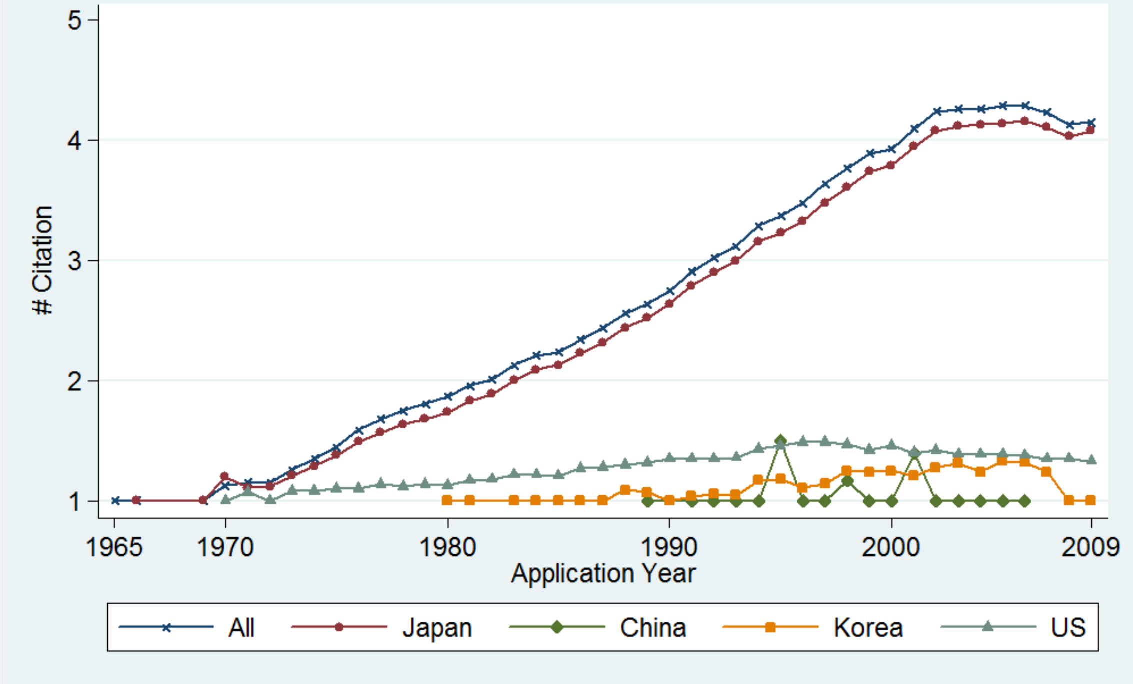


Figure 6. Average Patent Citations by Japanese Patents

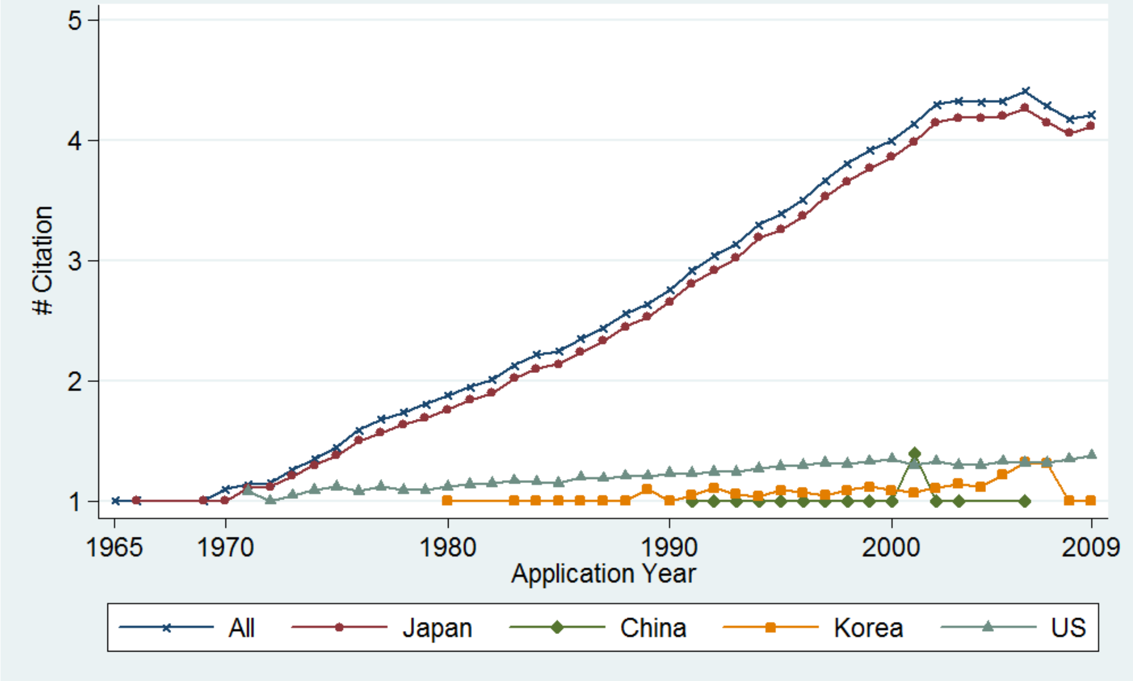


Figure 7. Average Patent Citations by Chinese Patents

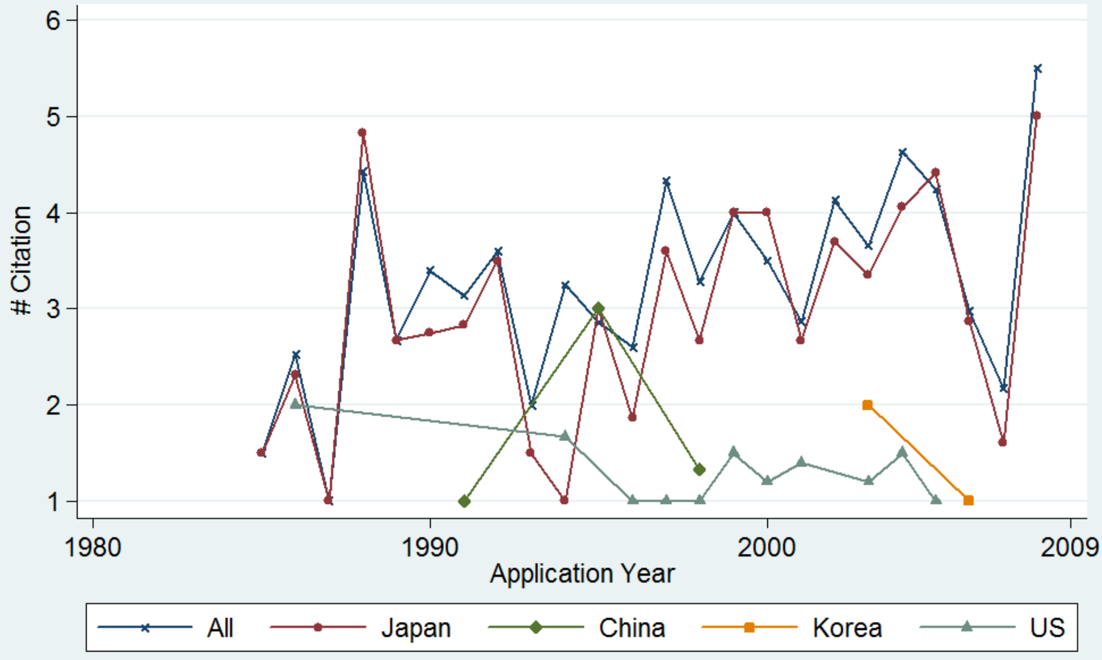
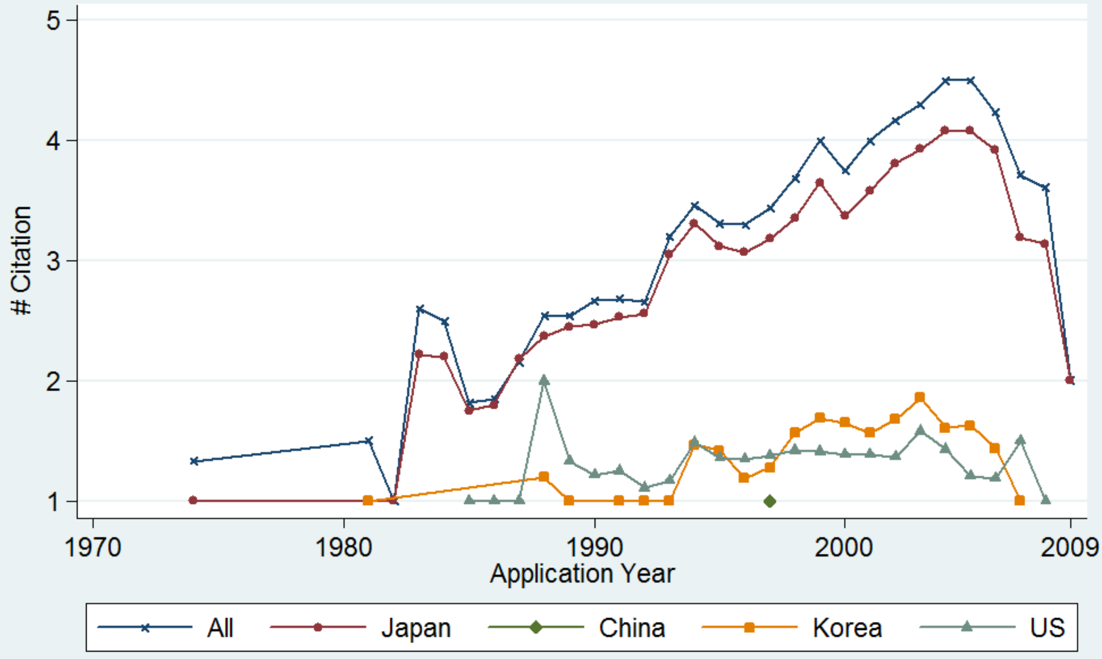


Figure 8. Average Patent Citations by Korean Patents



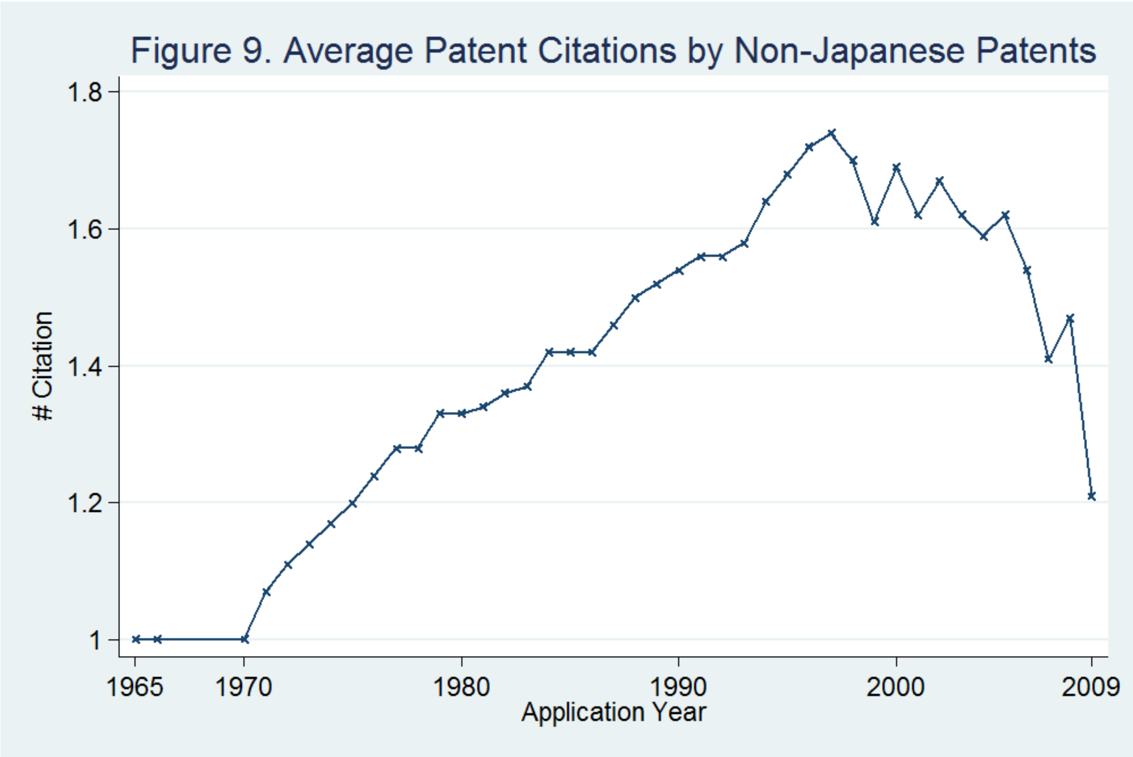


Figure 9. Average Patent Citations by Non-Japanese Patents

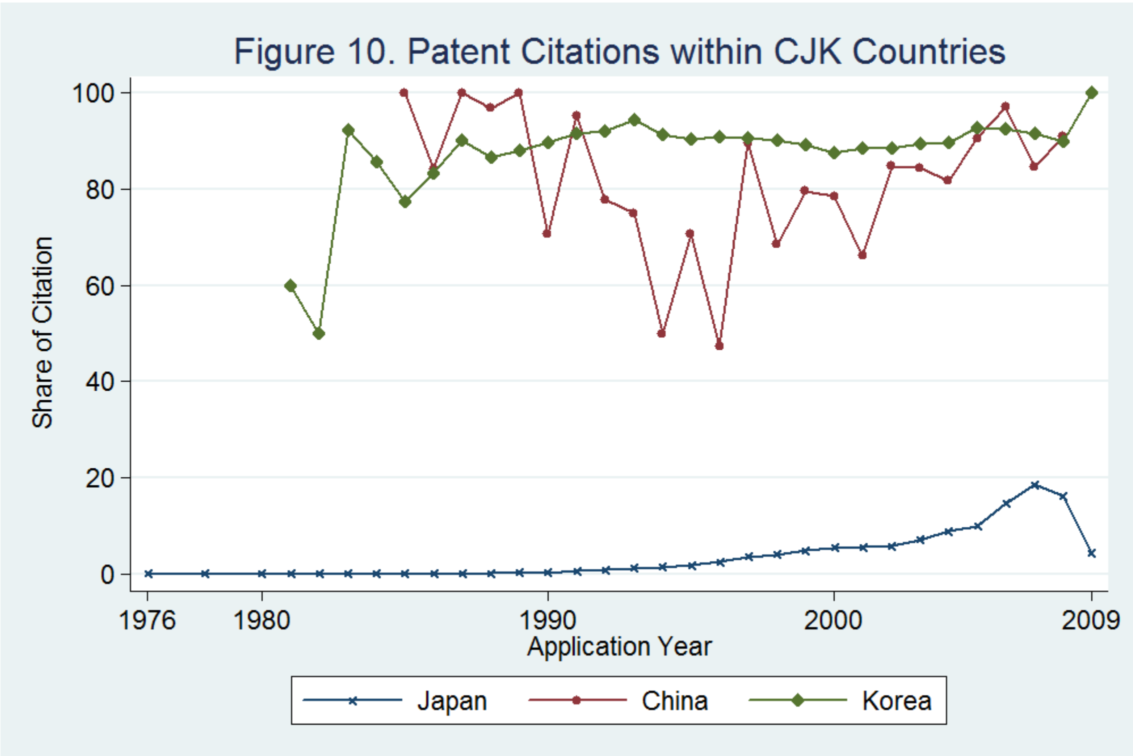


Figure 10. Patent Citations within CJK Countries

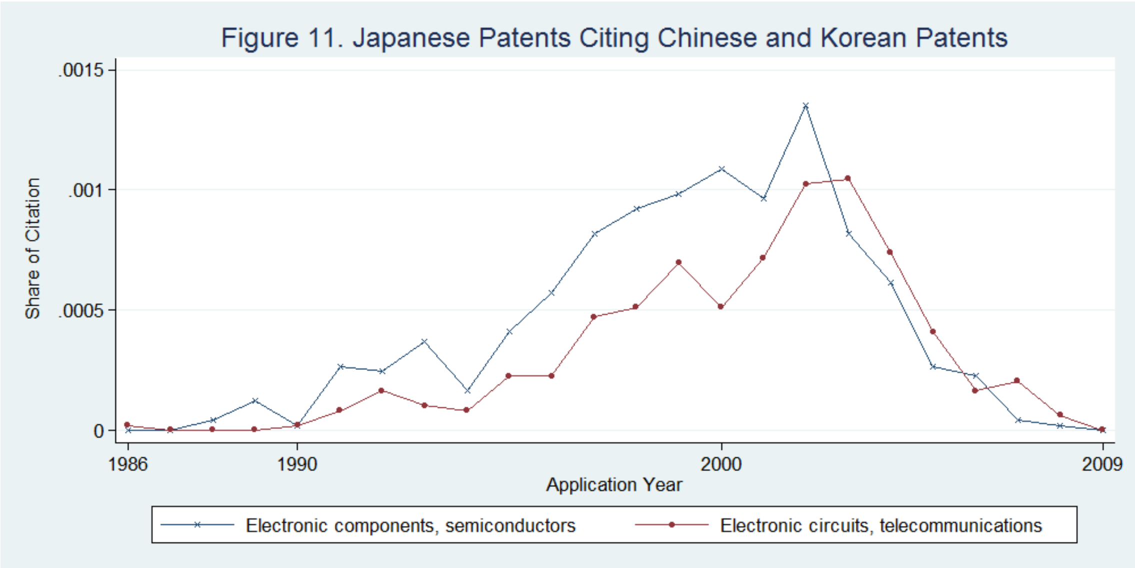


Figure 11. Japanese Patents Citing Chinese and Korean Patents
.0015
.001
.0005
0
Share of Citation
1986
1990
2000
2009
Application Year
Electronic components, semiconductors
Electronic circuits, telecommunications

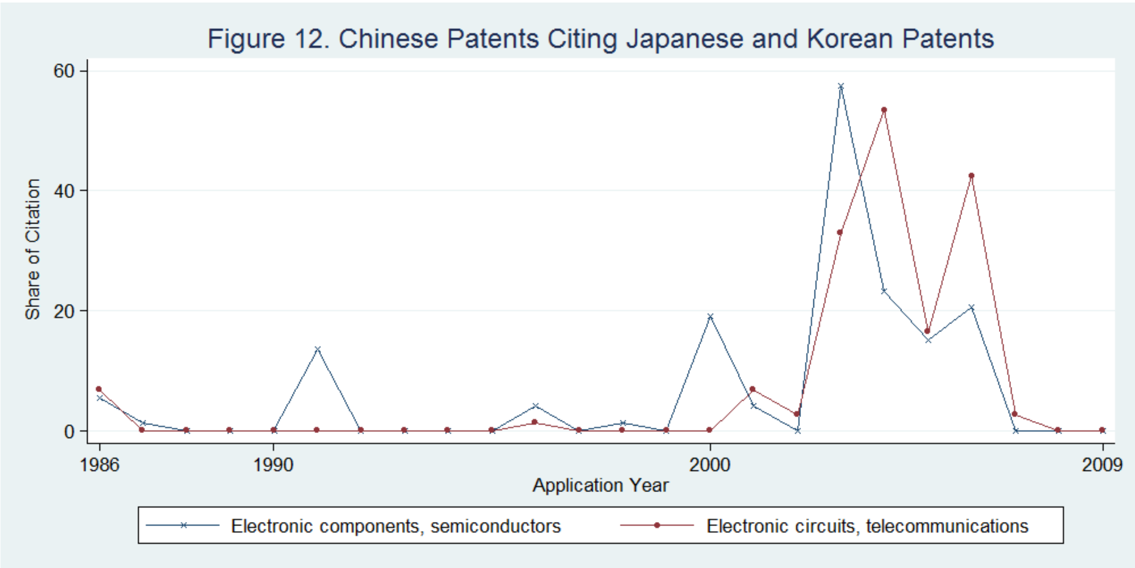


Figure 12. Chinese Patents Citing Japanese and Korean Patents
60
40
20
0
Share of Citation
1986
1990
2000
2009
Application Year
Electronic components, semiconductors
Electronic circuits, telecommunications

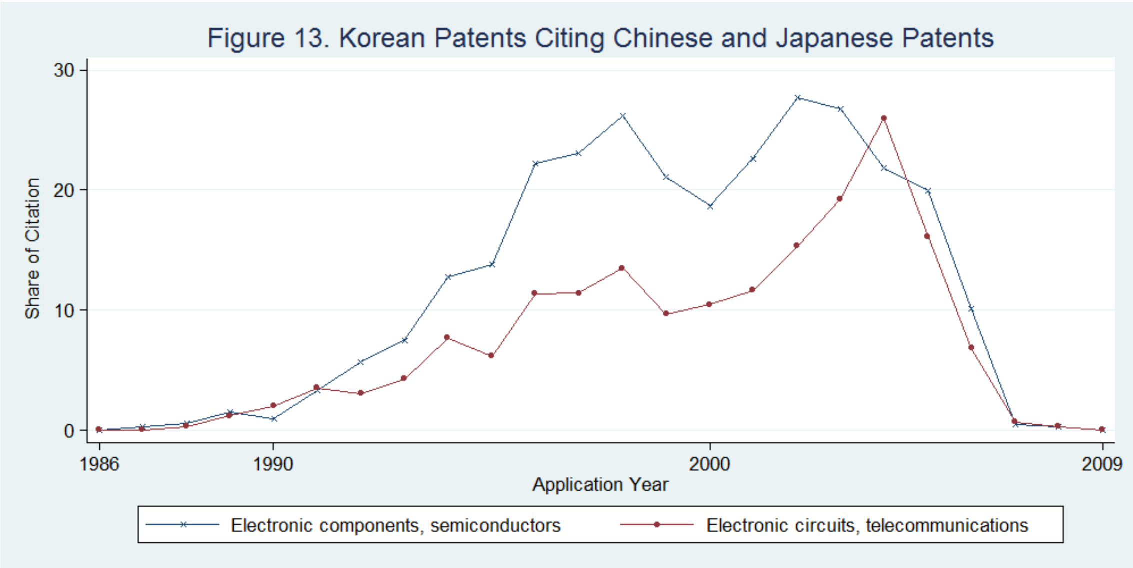


Figure 13. Korean Patents Citing Chinese and Japanese Patents
Share of Citation
30
20
10
0
1986
1990
2000
2009
Application Year
Electronic components, semiconductors
Electronic circuits, telecommunications

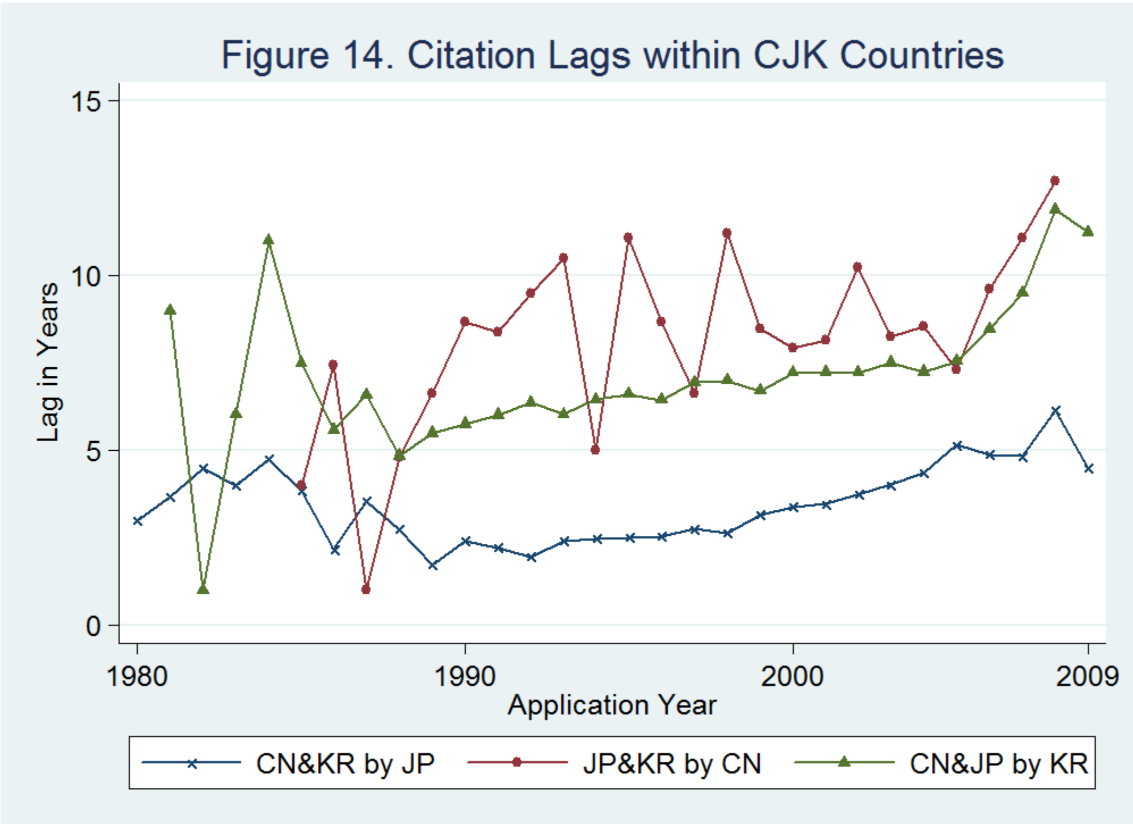


Figure 14. Citation Lags within CJK Countries
Lag in Years
15
10
5
0
1980
1990
2000
2009
Application Year
CN&KR by JP
JP&KR by CN
CN&JP by KR