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Intellectual Property Regimes, Innovative Capabilities, and Patenting in Korea

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Abstract

In this paper, we empirically investigate whether and to what extent major changes in IPR contributed to subsequent upgrading of innovative capabilities and patenting in Korea. We found that major IPR changes in Korea in the 1980s led to the big increase in patenting, thereby supporting the "friendly court" hypothesis. Especially, the trend of substance patent applications by local residents seems to suggest that the IPR change in Korea encouraged local firms to focus more on developing innovative capabilities and patenting more actively. Based on the Korean experience, we offer an insight into the recent debate on the relationship between IPR and economic development in developing countries.

Key words: intellectual property regime; patenting; innovative capabilities

INTRODUCTION

South Korea has achieved one of the highest GDP growth rate since Korea embarked on its first five-year economic development plan in 1962. What is more amazing in Korea's ascent in the world economy is the recent surge in Korean patents (Song,

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2002). The following statistics illustrate how quickly and drastically Korea has recently increased its patents.

- In terms of the number of patents registered in the U.S. Patent & Trademark Office (USPTO), Korea had only 2 patents in 1980. However, the total number of Korean patents registered in the U.S. in 2004 has increased to 4428. As shown in figure 1, the growth in Korean patents registered in the U.S. has accelerated over time, especially in the late 1990s. In 1995, Korea was ranked as # 21. But, in 1999, Korea emerged as # 6 in the U.S. patent ranking. In the 1990s, Korean patent registrations in the U.S. have increased by 36% annually, while the average growth rates for OECD countries and all the countries were 5.8% and 6.1% in the same period respectively (OECD, 2000).

- Samsung Electronics in Korea became the fourth largest patent registrant in the U.S. in 1999 — 5th in 2005 — just behind IBM (U.S.), NEC (Japan), and Canon (Japan) by registering 1545 patents. Samsung Electronics entered the top 100 patent registrant list in 1991 for the first time. The company rose to # 16 in 1997 and moved up to # 4 in just 2 years by almost tripling its patents registered in the U.S.

- In terms of international patent applications through the Patent Cooperation Treaty (PCT), Korea emerged as # 7 in 2004 by filing 3565 international patents.

How could Koreans achieve such a remarkable success in increasing the number of patents dramatically? What factors can explain the Korean success in improving innovative capabilities that led to the upsurge in Korean patents in the 1990s? This paper would attempt to seek an answer to these questions by focusing on how changes in intellectual property regime (IPR) in Korea influenced innovative capabilities and patenting of Korea.

By examining the relationship between IPR changes and patenting as an outcome of innovative capabilities in the context of Korea, this study intends to offer an insight into a recent debate on the impact of stronger IPR on the development of innovative capabilities of developing countries (Maskus, 2000a). Since 1980, Korea has changed its IPRs to upgrade itself from imitator to innovator. Korea's IPR focused on both technology creation and diffusion that are worth studying and showcasing for other developing countries that are faced with having to

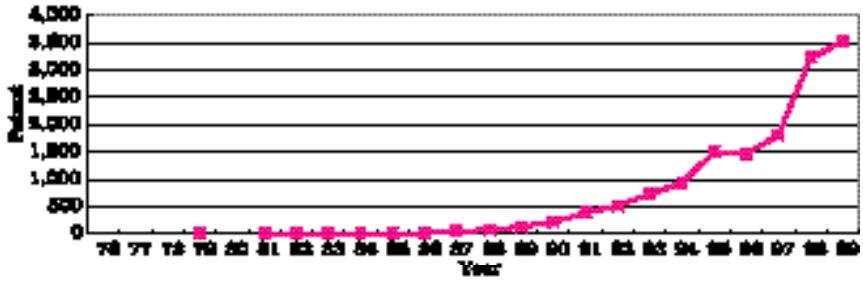


Figure 1. Number of U.S. Patent Granted to Korea

upgrade their regimes under the WTO mandate. In this paper, using our proprietary patent database, we investigate the impact of major changes in Korean IPRs on the upsurge in Korean patenting both at home and in the United States.

IPR, INNOVATIVE CAPABILITIES, AND ECONOMIC DEVELOPMENT

Recently, there have been heated debates on the impact of stronger IPR on economic development of developing countries (Maskus, 2000a). Generally, the objectives of the IPR can be divided into two categories: pro-creation and pro-diffusion. The pro-diffusion view emphasizes the role of IPR in diffusing existing technologies throughout the society either in the form of technology licensing or imitation. On the other hand, the pro-creation view focuses on the positive effect of IPR on the promotion of innovation. Unlike developed countries where the pro-creation role of IPR has been very effective and thus, dominant, developing countries with weak innovative capabilities often preferred the pro-diffusion role of the IPR. In this section, based on existing studies, we briefly describe relationships among IPR, innovative activities, and economic development with a special emphasis on the debate between the pro-creation view and the pro-diffusion view.

Pro-creation and pro-diffusion views of IPR

Governments often strengthen IPR in the hope of promoting

investments in knowledge creation and business innovation by establishing exclusive rights to use and sell newly developed technologies (Maskus, 2000b). IPR could help reward creativity and risk-taking among local firms and entrepreneurs, thereby promoting technical progress and economic development. Governments also aim at promoting widespread dissemination of new knowledge by encouraging intellectual property rights holders to place their inventions and ideas on the market.

Moreover, by strengthening IPR, governments also hope to attract foreign investments and advanced technologies. Foreign technology holders often refuse to license their latest innovations to firms in countries with weak IPR because they fear that the licensing contracts will eventually be unenforceable (Sherwood, 1990). Thus, local firms often find that weak IPR at home impedes their efforts to purchase technologies from abroad (Gould and Gruben, 1996). Mansfield (1994) suggested that a country's weak IPR indeed can deter foreign direct investments, especially those of R&D facilities.

Following the tradition of Schumpeter (1942), Romer (1991) argued that stronger protection of patents as the outcome of R&D investments should encourage innovation and economic development. Gould and Gruben (1996) showed that intellectual property protection is a significant determinant of economic growth by stimulating innovation. Maskus (2000b) also argued that inadequate IPR could stifle innovation and technical change even in under-developed countries because innovation in these poor countries are aimed at local markets and could benefit from domestic protection of patents. Park and Ginarte (1997) also argued that IPR affects economic growth indirectly by stimulating the accumulation of factor inputs like R&D and physical capital.

However, Park and Ginarte also found that IPR explains only the physical and research capital investment behavior of the top 30 advanced economies. Similarly, Helpman (1993) argued that developing countries could suffer from stronger IPRs because of higher imitation costs and the consequent reduction in technology availability. In support of the pro-diffusion perspective, he suggested that strengthening IPR in developing countries has a negative effect on the rate of innovation when imitation is the only channel of international production transfer. Glass and Saggi (1995) also contended that more protective IPR

could decrease the flow of technology transferred to developing countries.

This controversy may indicate that there exist two-way causal relationships between IPR and economic development. Rising income levels generate stronger incentives for upgrading IPRs, which in turn lays a foundation for further growth, especially for developed countries (Maskus, 2000a). As incomes rise, the demand for higher quality, differentiated products also rises, leading the growing preferences for stronger IPRs. On the other hand, IPR can play a positive role in promoting economic growth by encouraging new business development, rationalization of inefficient industry, and inducing technology acquisition and creation (Maskus, 2000b). For technology importing nations to benefit from stronger IPRs, there must be dynamic gains that could emerge over time. Such gains could come from enhanced flows of international trade, investment, and technology transfer (Maskus, 2000c).

Existing studies also indicate that the level of R&D investments are complementary to IPRs in determining the IPR's impact on economic development. Countries that do not conduct innovative research much would enjoy few, if any, of the benefits of strong IPR (Park and Ginarte, 1997). Countries without a strong domestic research base may find it difficult to justify providing IPR protection to foreigners, who seem to be the primary beneficiaries of protection, if in the short run, the consequences of IPR protection are higher prices of new technologies and limited diffusion. Park and Ginarte (1997) found that while R&D is an important determinant of economic growth for both developed and developing countries, IPRs matter for the R&D activities of the developed economies, but not for those of the less developed economies. In a sense, there may be two-way causal relationship between strong IPR and strong innovative R&D, mutually reinforcing each other. Similarly, countries that nurtured high-quality R&D researchers and engineers would have better ability to adapt imported technologies to local industrial uses and further develop new technologies and products, thereby generating stronger benefits from the IPR infrastructure.

Without such complementary investments in domestic R&D bases and human capital, developing a strong IPR in the context

of developing countries may be sometimes more harmful than beneficial, as Helpman (1993) and Glass and Saggi (1995) argued. This is because providing strong IPR is costly, especially for developing countries. Without strong enforcement of intellectual property protection, local firms in developing countries may be able to reverse engineer or imitate newly invented goods or processes and sell them to consumers at cheaper prices (Maskus, 2000a). Moreover, setting up and maintaining patent offices and courts is also costly (Siebeck, 1990). Accordingly, a country needs for a critical size of R&D investments to justify such costs.

In the subsequent section, we investigate the relationship among IPR changes, R&D investments, and patenting in the context of Korea. Especially, we examine to what extent major changes in IPR contributed to the upsurge in Korean patenting in the 1990s as an outcome of enhanced innovative capabilities.

EMPIRICAL ANALYSIS

Korea has been viewed as a model country of building innovative capabilities successfully in the economic development process. Thus, examining the relationships among IPR changes, R&D investments to build innovative capabilities, and patenting as an outcome measure of innovative capabilities in Korea may offer an interesting insight into the ongoing debate on the role of strong IPRs in promoting innovative capabilities and patenting as a basis of economic development.

Strong IPR in Korea

To investigate the role of IPR changes empirically, the most fundamental task is to measure the relative strength of IPRs on a consistent international basis. Recently, some scholars attempted to develop such a consistent international index of IPRs for cross-country comparisons, most notably the index developed by Ginarte and Park (1997). We use this index developed by Ginarte and Park — what we call the GP Index — for our empirical investigation of Korean IPR changes.

According to the GP Index, as shown in table 1, Korea rapidly

Table 1. Index of IPR (GP Index)

Country	1970	1980	1985	1990
Brazil	1.64	1.85	1.85	1.85
France	3.24	3.90	3.90	3.90
Germany	3.09	3.86	3.71	3.71
Hong Kong	2.04	2.24	2.57	2.57
India	1.42	1.62	1.62	1.48
Japan	3.32	3.94	3.94	3.94
Korea	2.94	3.28	3.61	3.94
Singapore	2.37	2.57	2.57	2.57
U.S.A.	3.86	4.19	4.52	4.52
Average	2.27	2.40	2.44	2.46
Maximum	3.86	4.24	4.52	4.52

Source: Ginarte and Park, 1997: 285-286.

increased the strength of its IPR in the 1980s for the protection of intellectual property rights of innovators. Even in the 1970s, Korea's GP Index was higher than the average. In 1970, Korea's GP Index value was 2.94, while the global average in the GP Index was 2.27. In the 1980s, Korea's GP Index jumped from 3.28 in 1980 to 3.94 in 1990. In 1990, the worldwide average for the GP Index was merely 2.46, a slight increase from 2.27 in 1970. The trend of the Korean GP Index confirms that major changes in IPR indeed occurred in the 1980s.

More importantly, the GP Index of Korea clearly shows that Korea introduced much stronger IPRs early on than other major developing countries such as Brazil, India, Hong Kong, and Singapore. In 1990, for example, Korea's GP Index was 3.94, whereas the values for Brazil, India, Hong Kong, and Singapore were only 1.85, 1.62, 2.57, and 2.57 respectively. These figures clearly show the pro-creation focus of the Korean IPR. Furthermore, Korea's GP Index even surpassed those of many developed countries by 1990. In 1990, France and Germany received lower GP Index values than Korea. Japan was tied to Korea in terms of the GP Index.

To examine whether Korea's IPR was much stronger than predicted by per capita GDP, we ran a simple regression using a sample of 48 countries. As shown in figure 2, in a regression of the GP Index as of 1990 on per capita GDP for the same year,

Korea's GP Index was out of the upper limit of the 95% confidence level of the regression, confirming statistically that Korea adopted a much stronger IPR than warranted by per capita GDP.

Upsurge of Korean Patenting and the Friendly Court Hypothesis

We further investigate whether and to what extent major changes in IPR contributed to the rapid development of Korea's innovative capabilities and upsurge of patenting as a consequence. Kortum and Lerner (1999) empirically examined the conventional view (e.g., Merges, 1992) that the establishment of the Court of Appeals of the Federal Circuit by Congress in 1982 triggered the subsequent surge in U.S. patenting since the 1980s. They called this view a "friendly court hypothesis." In the empirical examination of the recent surge in Korean patenting, we test the friendly court hypothesis that emphasizes the positive effects of stronger intellectual property protection by law and court orders on motivations to innovate and patent.

Kortum and Lerner (1999) tested the friendly court hypothesis by examining the changes in the number of patents in the U.S. as a patenting destination. Kortum and Lerner assumed that if the friendly court hypothesis is right, then both U.S. and foreign firms should find patenting in the U.S. increasingly attractive and thus, increase in patenting should be relatively uniform across the types of patentees — domestic residents or foreign residents. In their empirical examination, the friendly court

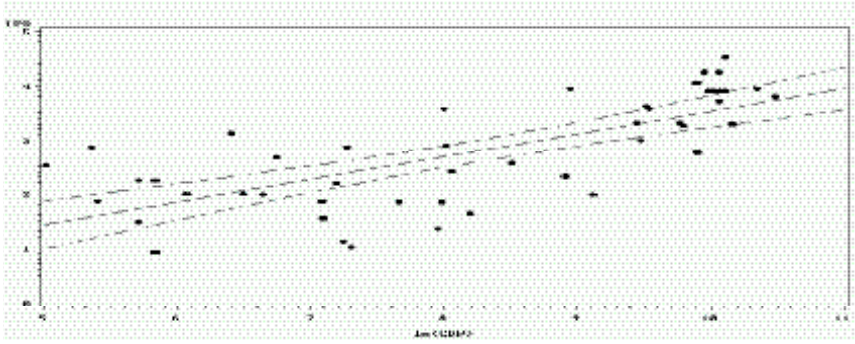


Figure 2. Simple Regression of IPR on GDP

hypothesis was not accepted because foreign patent applications in the United States did not increase as much as domestic residents' applications after the major IPR change in the early 1980s.

Using the Korean patent data, we did the similar test to examine how important major IPR changes in Korea were in the dramatic increase in Korean patenting. The first task for this investigation was to identify major IPR changes in Korea. To do so, we conducted interviews with local experts at KIPO and patent lawyers. We also reviewed existing studies of IPR changes in Korea. Based on our interviews and literature review, we concluded that there were three major changes in Korean IPRs since the 1970s. The three major changes that we identified are as follows:

(1) 1980-1982: Revision of the patent law in 1980 in compliance with the Paris Convention for the Protection of Industrial Property and the subsequent revision of the patent law in 1982 in compliance with the Patent Cooperation Treaty (PCT)

(2) 1986: Revision of the patent law in 1986 to introduce the substance patent for pharmaceutical and chemical materials

(3) 1995-1997: Revision of the patent law in 1995 in compliance with Uruguay Round/Trade Related Aspects of Intellectual Property Rights (UR/TRIPs) as well as to reform the appeals/trials system; Revision of the patent law in 1997 to introduce opposition to the grant of patents after registration

For our empirical investigation, we focused on the first two changes because we do not have enough time series to investigate the effects of the last change that was made in the late 1990s. If we borrow Kortum and Lerner's testing method of the friendly court hypothesis, patent applications by foreign residents should increase at least as much as those by local residents. Figure 3 shows the trend of patent applications by both local and foreign residents. Figure 4 highlights the trend of foreign patent applications in Korea as opposed to the total patent applications. Figure 4 shows that foreign patent applications in Korea had two major inflection points in the 1980s. The first jump in foreign patent applications took place in 1983 just after the major changes in Korean IPRs between 1980 and 1982. Then the second jump in foreign patent applications occurred around 1986 and 1987 just after the introduction of the

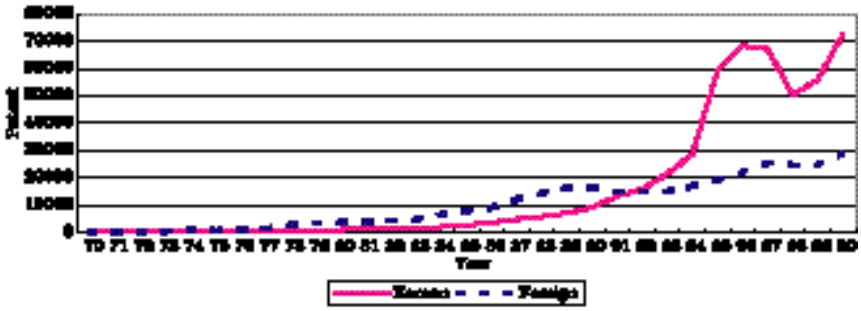


Figure 3. Trend of Domestic Patent Applications by Types of Applicants (Korean applicants Vs. Foreign applicants)

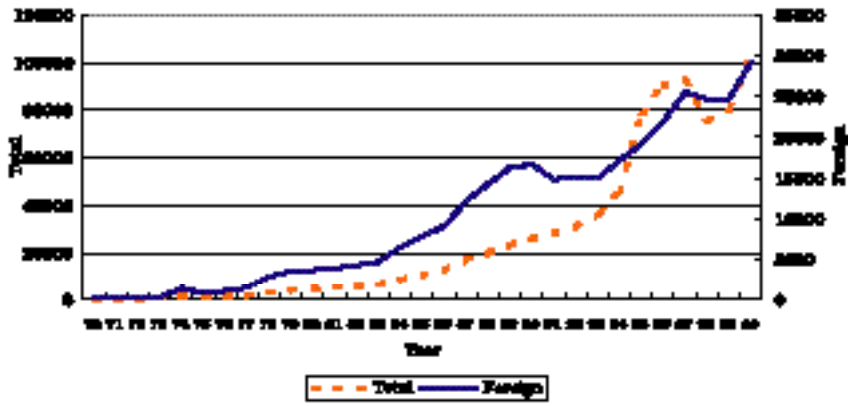


Figure 4. Trend of Domestic Patent Applications by Types of Applicants (All applicants Vs. Foreign applicants)

substance patent in pharmaceutical and chemical areas. We should also note that in the 1980s when the major IPR changes were made in Korea, the growth rate of patent applications by foreigners was higher than that by local residents, although patent applications by the latter has also increased steadily in this period. These patterns appear to support the friendly court view that major IPR changes indeed are important in patenting in Korea.

To check whether the jump in patent applications by foreigners was a unique phenomenon in Korea, we compared the trends of patent applications by Japanese and Germans in Korea with

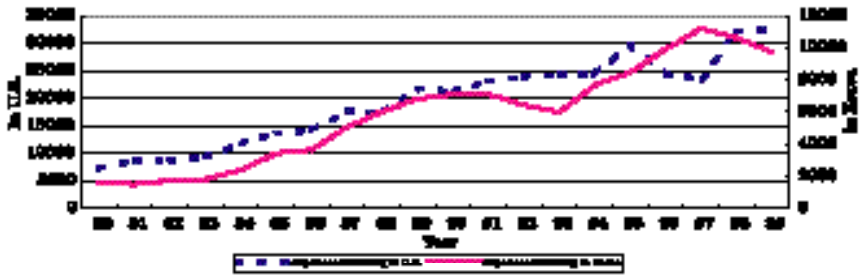


Figure 5. Comparison Japanese Patenting in Korea Vs. in the U.S.

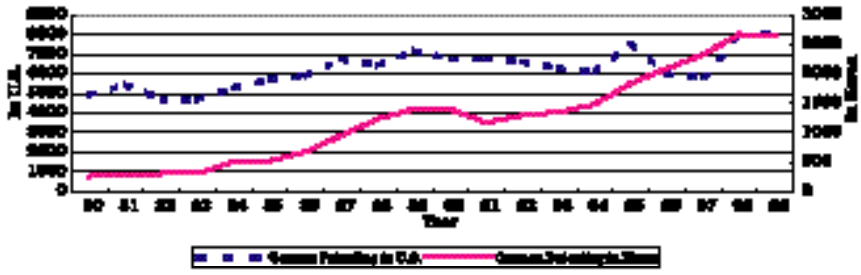


Figure 6. Comparison German Patenting in Korea Vs. in the U.S.

those in the U.S. Figures 5 and 6 show the Japanese and German patent applications in Korea and in the U.S. respectively. In both figures, we learned that the jump in the Japanese and German patent applications in Korea around 1986 and 1987 were a largely unique phenomenon. There was a similar surge in patent applications by Japanese and Germans in both Korea and the United States around 1982. The surge in the U.S. appears to reflect major changes in IPRs in the U.S. as well. In addition, the growth rate of Japanese patent applications in Korea appears to be higher than that in the United States in the 1980s.

To examine the effect of IPR changes on the increase in patent applications more formally, we did a series of T-tests (tables 2 and 3). Results from the paired t-tests of patent growth rates of Japan and Germany in Korea and the U.S. between 1983 and 1991 respectively confirm that the patent growth rate in Korea was significantly higher than that in the U.S. for both Japanese

Table 2. T-Test of Growth Rate of Japanese Patents in Korea Vs. in the U.S.

	Mean	Standard Deviation	t-value
Growth rate in Korea Vs. Growth rate in the U.S.	.1733	.2350	2.213*

Note: *: p=0.1; **: p=0.05; ***: p=0.01

Table 3. T-Test of Growth Rate of German Patents in Korea Vs. in the U.S.

	Mean	Standard Deviation	t-value
Growth rate in Korea Vs. Growth rate in the U.S.	0.076	.1407	1.835*

Note: *: p=0.1; **: p=0.05; ***: p=0.01

and German patents at the significance level of p = 0.1.

We further investigated the effects of the introduction of substance patents in 1986 on the subsequent increase in patenting in Korea. Table 4 shows the trends of substance patent applications in Korea after the revision of the patent law in 1986. Just after the introduction of substance patents, foreign residents' applications of substance patents poured in. Unfortunately, we do not have the annual data on substance patent counts between 1987 and 1990, but on average, foreigners filed almost 1500 substance patents annually in 1987-1990. After a big wave of substance patent applications in the late 1980s, the annual count of substance patents filed by foreigners has decreased until 1994 and then rebounded again only after 1996. We should also note that substance patent applications by foreigners were more than 15 times as high as those by local residents in the late 1980s, suggesting that foreigners were initial beneficiaries of the major IPR change in Korea. To sum up the analysis above, we can conclude that the higher growth rate of patent applications by foreigners than that by local residents just after the major changes in IPRs in Korea in the 1980s appear to provide a supporting evidence of the "friendly court" argument.

However, the impact of these major IPR changes on patent

Table 4. Trends of Substance Patent Applications in Korea (Counts)

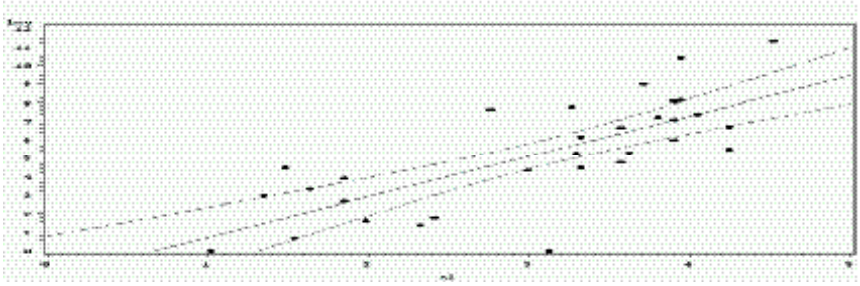
Year	87~90	91	92	93	94	95	96	97	98
Local Residents	354	161	178	243	346	311	347	582	547
Foreign Residents	5,950	1,448	1,214	1,078	1,098	1,147	1,084	1,343	1,482
Total	6,304	1,609	1,392	1,321	1,444	1,458	1,431	1,925	2,029

Source: KIPO

applications by local Korean residents is less certain. Given that we are mainly interested in the upsurge in Korean patenting over time, what is more relevant to this study is the impacts of major IPR changes on Korean patenting activities rather than those of foreigners in Korea. To examine the effects of major IPR changes on Korean patenting more formally, we ran a simple regression of U.S. patent counts in 1998 on the IPR index of 1990. We used the IPR index developed by Ginarte and Park (1997) and constructed the country-level data set based on the availability of the IPR index. To avoid potential simultaneity and reflect the lagged effects of IPR on building innovative capabilities and then obtaining patents, we gave an 8-year time lag. The result from a linear regression in figure 7 shows that Korea's patent counts in the U.S. is slightly out of the upper limit of the 95% confidence level (the upper and the lower dotted lines in the figure) along the regression line, suggesting that Korea obtained significantly more patents than the simple regression predicted based on its relative IPR index.

To obtain a more direct evidence of the positive effect of stronger IPR on building innovative capabilities of Korean firms, we further investigated the case of Korean pharmaceutical and chemical firms. As we mentioned above, just after the introduction of substance patents, foreign residents applied for almost 6000 substance patents in just four years (see table 4). In the late 1980s, substance patent applications by foreigners were more than 15 times as high as those by local residents, suggesting that foreigners, mostly American, Japanese, and European pharmaceutical and chemical firms, were initial beneficiaries of the major IPR change in Korea.

Not surprisingly, the introduction of substance patents in 1986 hit the Korean chemical and pharmaceutical companies hard because they used to copy foreign technologies and products.



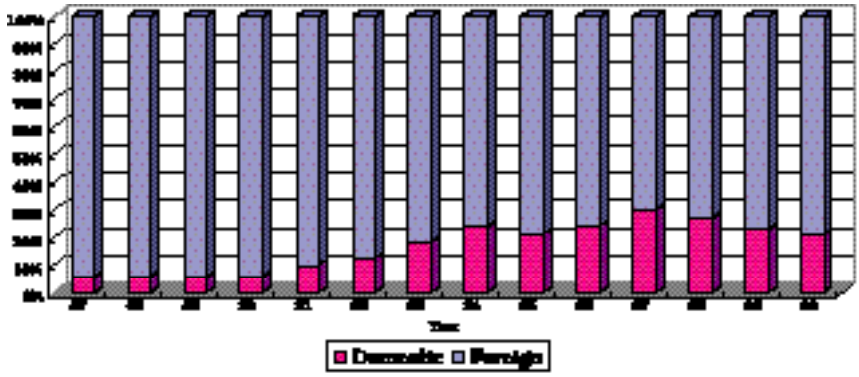
Note: X1 = IPR Index in 1990 (based on Ginarte and Park, 1997); LnY = natural log of U.S. patent counts in 1998

Figure 7. Relationship Between the IPR Strength and Income Levels

Because most of them did not conduct serious innovative R&D before the introduction of substance patents, in the late 1980s, the share of domestic applications was far less than 10%.

However, fierce competition from multinational corporations in the home turf made these Korean companies shift their focus rapidly towards more innovative R&D and alliances with technology holders abroad. Their desperate efforts for innovative R&D for survival began to pay off in the mid-1990s. As shown in figure 8, the share of applications by local residents was up to almost 30%, although the ratio dropped again due to the financial crisis in 1997. The rapid increase in substance patent applications by local residents seems to suggest how changes in IPR can influence the direction and the intensity of R&D by indigenous firms by imposing more intense competitive pressures, especially from multinational corporations.

We found additional evidence of the positive role of IPR changes in promoting innovation and patenting. Recently, the Korean government paid attention to the rapidly increasing use of Internet and the proliferation of electronic commerce-related start-ups. In order to cope with this new trend, KIPO instituted the Examination Guideline for E-Commerce Related Inventions in 2000. Under the new guideline, so-called business model patents (BM patents) can be patentable. After the institution of the new guideline, the number of applications for e-commerce related patents have soared almost 9-fold from 1133 in 1999 to 9895 in 2000, as shown in figure 9. The upsurge of BM patents



Source: KIPO, 2001

Figure 9. Application Trend of E-Commerce Related Patents

after a related IPR change offers another supporting evidence of the positive impact of the IPR changes on technical changes and patenting.

Finally, we examined whether stronger IPR can also encourage local companies to spend more money conducting innovative R&D. The R&D intensity that is defined as the ratio of R&D expenditures to GDP in Korea rose substantially in the 1990s. The share of R&D expenditure to GNP in Korea was merely 0.58% in 1980. However, the ratio has risen sharply and by 1990, it reached almost 2%. The trend was accelerated in the 1990s until the economic crisis in 1997 and the ratio was up to

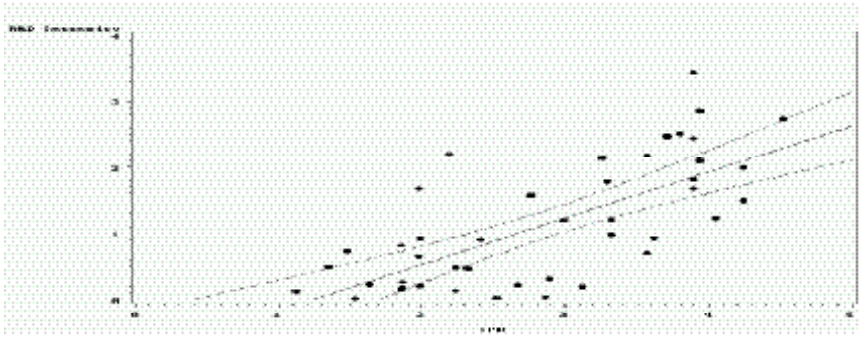


Figure 10. Simple Regression of the R&D Intensity on IPR

almost 3% in 1997. By the late 1990s, the R&D intensity of Korea was even higher than that of Germany, U.K., or France. To examine whether the R&D intensity of Korea is significantly higher than predicted by the level of IPR, we ran a simple regression of the R&D intensity in 1992 on the GP Index of IPR as of 1990. As shown in figure 10, the R&D intensity of Korea is above the regression line, but within the boundary of the 95% confidence level.

Pro-diffusion perspective of IPR in Korea

Although the Korean government clearly emphasized the pro-creation role of the stronger patent protection in its IPR, the government also believed that stronger patent protection is likely to lead to more active technology transfer from multinational corporations with less fear about illegal technological leakages (interviews at KIPO and Kim & Chang). Figure 11 below shows how the number of technology licensing from abroad in the chemical industry has increased over time. Technology licensing has increased substantially around and after the introduction of substance patents in 1987 and then decreased sharply in the 1990s. Figure 12 shows that there was a substantial increase in foreign direct investments in the chemical industry in the late 1980s as well. These figures indicate that in response to the introduction of substance patents, a substantial number of multinational chemical companies decided to make technology licensing or direct investments in Korea. The sharp decrease in

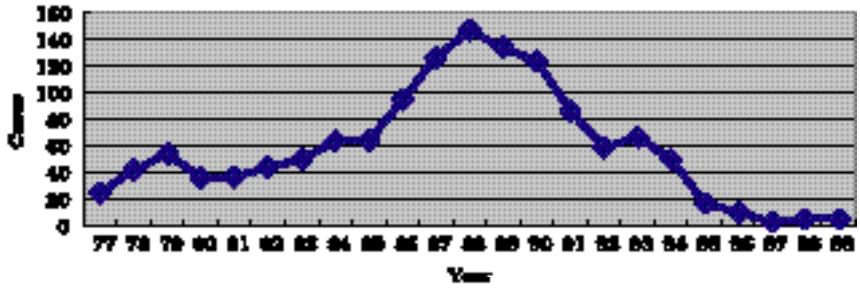


Figure 11. Trend of Technology Licensing in the Chemical Industry (# of cases)

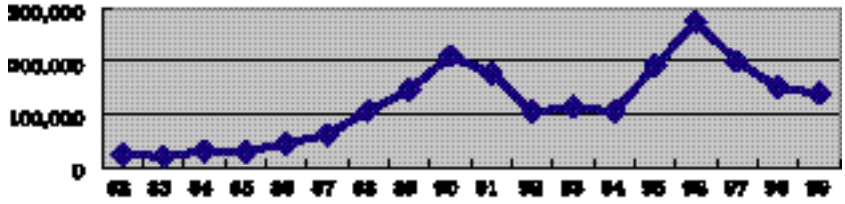


Figure 12. Foreign Direct Investments in the Chemical Industry (unit: 1000 US $)

technology licensing from foreign firms in the 1990s may also offer an indirect evidence of improved technological capabilities of Korean chemical firms as a result of a sharp increase in R&D efforts in response to the introduction of substance patents. The patterns are similar in the pharmaceutical industry.

These data seem to show that the pro-creation role of the IPR may not be necessarily incompatible with the pro-diffusion role of the IPR. As shown in the Korean pharmaceutical and chemical industry cases after the introduction of the substance patents, the government policy to strengthen the stronger intellectual property protection appear to induce more technology licensing as well as promote more investments of domestic firms in R&D and innovation.

CONCLUSION

In this paper, we empirically investigated to what extent major

changes in IPR influenced subsequent upgrading of innovative capabilities and patenting in Korea. To sum up our findings, since 1980, Korea has made major changes in IPR. Initially, major IPR changes in Korea were triggered by the pressure from the U.S. government, but the Korean government also attempted to push local companies to transform themselves from imitators to innovators by strengthening IPR. As a result, in 1990, Korea's IPR index was much higher than the global average and even higher than those of France and Germany.

We found that major IPR changes in the 1980s led to the big increase in patenting, thereby supporting the "friendly court" hypothesis. Especially, the trend of substance patent applications by local residents seems to suggest that the IPR change indeed encouraged local firms to focus more on developing innovative capabilities and patenting more actively.

The Korean experience appears to offer an important insight into the recent debate on the relationship between IPR and economic development in developing countries. Major changes in the Korean IPR appear to have influenced the shift of private corporations' strategic focus towards more R&D and innovation-driven growth strategy under the more intense competition from foreign multinationals, thereby promoting economic development. In this respect, the Korean IPR, especially the legal framework, is mainly pro-creation-oriented. However, we should note that as evidenced by the introduction of substance patents, the stronger protection of the intellectual property rights also motivated foreign firms to license their technologies more actively to Korean firms, thereby promoting the diffusion of patented technologies. In conclusion, IPR changes in Korea seem to have contributed positively to the upgrading of innovative capabilities and the upsurge of patenting.

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