BACKGROUND PAPER

Diverse Forms of Intellectual Property Rights, Innovations, and Firm Performance at Different Stages of Development: Findings from the Firm-Level Study in the Republic of Korea, 1970s–2010s

Keun Lee, Raeyoon Kang, and Donghyun Park

DIVERSE FORMS OF INTELLECTUAL PROPERTY RIGHTS, INNOVATIONS, AND FIRM PERFORMANCE AT DIFFERENT STAGES OF DEVELOPMENT:

FINDINGS FROM THE FIRM-LEVEL STUDY IN THE REPUBLIC OF KOREA, 1970s–2010s

Keun Lee
Professor, Economics Department, Seoul National University, Seoul, Republic of Korea
kenneth@snu.ac.kr

Raeyoon Kang
Researcher, Institute of Economic Research, Seoul National University, Seoul, Republic of Korea
raeyoonk@gmail.com

Donghyun Park
Principal Economist, Asian Development Bank
dpark@adb.org

30 November 2019

Abstract

Traditional literature on the role of intellectual property rights (IPRs) in innovation and economic growth tends to focus on the strength of IPR protection, given the tradeoffs between innovation and diffusion. From development perspectives, recent literature has shifted attention to diverse forms of IPRs in promoting innovation and growth, considering not only regular invention patents, but also utility models (petite patents) and trademarks (Kim et al, 2012; Kang et al. 2019). The present study extends this focus to the role of designs at different stages of development and uses firm-level IPR (patents, designs, and trademarks) data from the Republic of Korea. Covering over five decades, the data can be divided into three sub-periods that represent different stages of development, such as from the 1970s to the 1980s, the late 1980s to the 1990s, and in 2000-2009. Results show that design-intensive sectors differ from trademark-intensive sectors and tend to be more export-oriented and less capital-intensive. Firm-level analysis finds that, in such design-intensive or export-oriented sectors, firms' sales growth is significantly associated with high-design intensity (number of designs to sales ratio) of firms. In the Republic of Korea, such association is found only after firms reach a certain level of capability, or since the 1990s, but not at the earlier stages of development, such as from the 1970s to the 1980s, when petite patents were considerable. Combined with existing research literature, this finding implies that different stages of economic development require not only different levels of IPR protection but also different forms of IPRs. The sequence is from petite patents at an earlier stage to designs in export-oriented sectors or trademarks in domestic market-oriented sectors, and finally to emphasis on patents at the later stage of development or firms at a higher level of capabilities.

Keywords

intellectual property rights, patents, designs, trademarks, utility models; economic development, firm growth

JEL Classifications

O3; O1; O2

I. INTRODUCTION

In a knowledge-based economy, technological innovation and intellectual capital are important determinants of economic growth. Intellectual property rights (IPRs) are one of the most powerful intangible assets that constitute a firm's capability. Lee (2013) describes the capability-based view to explain the Korean and Asian experience in the catching-up development process. This approach can be considered as an extension of the technology-based view (Organisation for Economic Co-operation and Development (OECD) 1992; Hobday 1995; L. Kim 1997), wherein firms' accumulated capability has sustained economic growth in the Republic of Korea (ROK) for several decades.

The classical issue on the relationship between IPR and innovation has been whether the strong or weak protection of IPR stimulates innovation (Maskus and Penubarti 1995; Smith 1999; and Awokuse and Yin 2009). However, without innovation capability, nothing is produced even with a strong IPR (Lee 2019). Thus, from the strength of protection on economic growth at different stages, recent literature tends to shift the focus to the roles of diverse forms of IPR. Kim et al. (2012) show that, in developing countries, the simple strengthening of patent rights does not promote innovation and growth, whereas minor forms of IPR such as utility models (often called petite patents) have significant impacts on innovation and growth. [1] Lee (2019) and Kang et al. (2019) observe two different paths of technological development, namely, patent-driven path versus trademark-driven path. The paths depend on the nature of sectors, some of which rely more on trademarks than patents in their IPR strategies. For instance, trademarks are more important when the innovation involves tacit knowledge that cannot be filed as patents, or when firms are more oriented toward domestic markets than world markets. Literature on trademarks regard them not only as an expressions of quality and variety of products (Block, Fisch, Hahn, and Sandner 2015; and Sandner and Block 2011), but also as a measure of product innovation (Mendonça, Pereira, and Godinho 2004).

Attention shift is observed from the strong versus weak protection of IPR to its diverse forms at different stages of development, such as regular invention patents, petite patents, trademarks, and

---

[1] Patents protect innovations of relatively high inventiveness, whereas utility models protect those of relatively low inventiveness. The latter offers second-tier protection for minor inventions that exhibit a practical or functional advantage over existing ones. Utility models are thus usually sought for small, marginal innovations that may not meet the patentability criteria (Bently and Sherman 2001, and Beneito 2006).

design patents. Conventional patent rights alone are not effective in promoting innovation, particularly imitative innovation. This issue is important in developing Asia, which is facing the challenge of managing the transition from imitation to innovation. Therefore, the present study seeks to determine what would be the effective strategies and policies regarding diverse forms of IPR to promote innovation at different stages of development.

Given this research question, the grand hypothesis is that the different stages of development at different income levels require emphasis on different IPR forms. Kim et al. (2012) show that, at the earlier stage of development, utility models may serve as an import vehicle to recognize and promote imitative innovations (or innovation with minor degree of invention). Specifically, the current study focuses on design, which is the least studied form of IPR in economics.

We use firm-level IPR (patents, designs, and trademarks) data from the ROK. Covering a period of five decades, the data can be further divided into three sub-periods representing different stages of development, such as from the 1970s to the 1980s, the late 1980s to the 1990s, and in 2000-2009. Results show that, first, design-intensive sectors differ from trademark intensive sectors. The former tends to be more export-oriented, less advertising-intensive, and codifiable knowledge-oriented. Second, such design-intensive or export-oriented sector firms' sales growth is largely associated with high design intensity (number of designs to sales ratio) of firms. In the ROK, such association is found only after firms reach a certain level of capability, or since the 1990s, but not at the earlier stage of development, such as the 1970s to the 1980s, when petite patents were considerable.

Section 2 discusses the roles of diverse IPR forms in economic development and growth of firms in the ROK. Sector 3 conducts sectoral-level analysis to reveal the nature of design-intensive sectors. Section 4 performs firm-level empirical analysis to determine the linkage from IPR forms (designs and patents) to firm performance measured by sales growth. The last section provides a summary and discussion of policy implications.

II. DIVERSE IPR FORMS AND ECONOMIC DEVELOPMENT

A. Development of Intellectual Property Rights in the Republic of Korea

First adopted in 1908, during the last era of the Joseon dynasty, the IPR system in the ROK has grown with the country's economic development. However, the Japanese IPR system was used when the ROK was under the intervention of Japan. The first patent in the ROK was "hat made of horsehair" by Inho Jung. In 1946, 1 year after the ROK's independence from Japan, the patent law (United States military government command No. 91) was enforced covering patents, utility models, and designs. In 1949, the trademark law was established and the patent bureau was created as an external agency of the Ministry of Commerce and Industry. [2]

After the Korean War in 1953, the Korean economy was largely based on agriculture and had no resources for development or perceptions of technology. Given the widespread collusion between politics and business in domestic companies, the government could not lead the country to economic growth. Most registered IPRs were by foreign companies or individuals. The foreign country with the most registered IPRs in the ROK was the United States, from where the IPR law was based.

The Korean IPR system was established in 1961 after the success of the military coup on May 16. The military government encouraged society-wide reform and modified whole entire systems of law. Consequently, the patent law (No. 950), utility model law (No. 952), and the design law (No. 951) were promulgated on 31 December 1961. The trademark law (No. 1295) was amended on 5 March 1963. These laws are the substructure of the present Korean intellectual property

---

[2] The first patent "The processing of *sulphur dye*" was by Central Research Institute for Industry (1948); the first utility model "Cart for children" was by Kyoungchul Shin (1948); the first design "The shape and color of half badged coat string" was by Changrok Chio (1948); the first trademark 天, was by Chunil Industry (1950).

legislation, which has been amended more than 20 times since 1961 to keep up with rapid changes in economic environment and technological development.

In 1962, the full-scale development of the Korean manufacturing industry began with the 5-year economy-driving plan of the government with light industries, such as apparel and shoemaking. After the third economic development plan in 1972, the main industry changed to heavy and chemical industries, such as steel, oil refining, and shipbuilding. In the 1970s, the government emphasized technological development by publicly funding and conducting research and development (R&D) (Lee 2013). However, the granted patents and utility models did not significantly increase. Until the 1970s, trademarks and designs were registered more frequently than patents and utility models.

In the 1980s, intensified R&D expenditure and higher education than the previous period laid the foundation for knowledge-driven growth. The Special National R&D Program was launched in 1982 with a total investment of W334 billion, with W194 billion from the government and W140 billion from the private sector (Branscomb and Choi 1996). From the mid-1980s, Korean firms started to establish their own private research centers because they realized the limitation of licensing and embodied technology transfer (OECD, 1996). High-tech sectors, such as machinery, semiconductors, automobiles, and electronics, fully settled down through public–private research cooperation. Intellectual property protection of patents became stronger and the registration of utility models and patents started to increase (Kim et al. 2012).

The 1990s was a turbulent decade for the Korean economy. Several Korean firms, such as Samsung Electronics, LG Electronics, and Hyundai Heavy Industries, became the most important players in global markets in their own industries in the early 1990s. Samsung Electronics became

the market leader in the production of DRAM memory in 1992. The Korean electronics industry moved to high-tech products during this period, and independent enterprise research institutes for large companies were established. The number of research centers increased from 261 in 1986 to 1,663 in 1994. As a result of economic and political preparation for many years, the ROK finally joined the OECD in December 1996.

However, in the following year, the ROK suffered a financial crisis and needed to ask for a bailout from the International Monetary Fund. To overcome the crisis, the ROK carried out numerous institutional and policy reforms. Choo et al. (2009) state that technological capabilities are important in explaining the post-crisis performance of surviving Korean firms, especially the chaebols.

After the crisis, many firms (even chaebols) went bankrupt and numerous people were laid off. However, the firms that succeeded in accumulating technological capability survived. In 2008, the Korean economy experienced another financial crisis. After undergoing these harsh periods, the government and firms realized the importance of intangible assets such as IPRs.

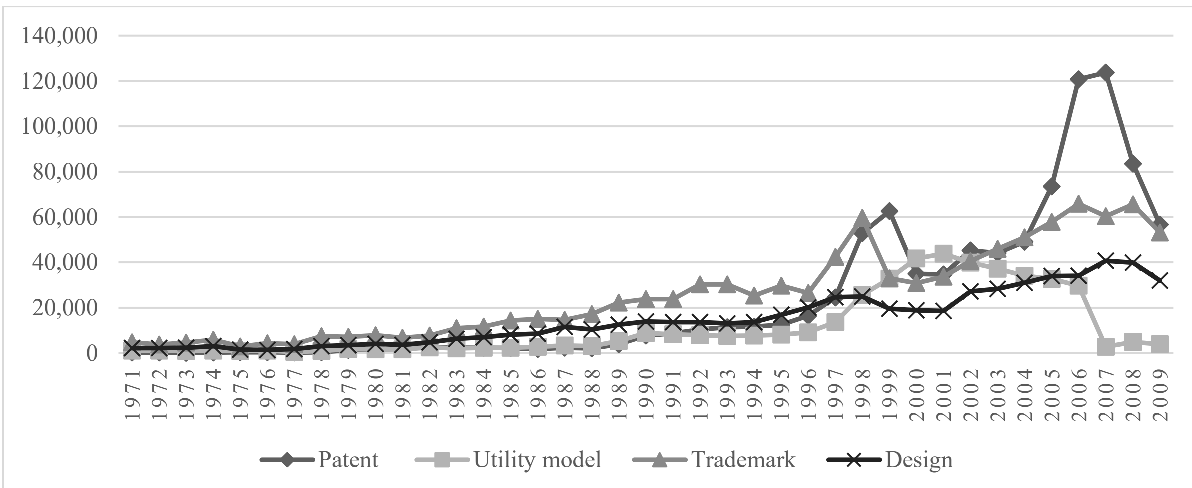
In 2000-2009, patents maintained the largest number of IPRs; trademarks and designs also exceeded 20,000 registrations per year by total assignees and 10,000 registrations per year by firms. The total number of IPRs was about 2,200 times higher than in the 1950s. The registration of utility models rapidly diminished because the process of registering utility models changed to an evaluation system from 2006; patent registrations decreased given that large firms, such as Samsung and LG, have reduced registration of patents in the Korean Intellectual Property Office (KIPO). [3]

---

[3] From the early 2000s, large firms applied and registered patents in USPTO to compete at the global market instead of

As followers, the lack of local technological capability made Korean firms heavily dependent on reverse engineering and imported equipment or machinery before the 1980s (Lee et al. 2003). After accumulating technological capabilities, Korean firms were expected to adopt strategies similar to those of advanced countries. In the ROK, the number of IPR registrations per year increased from 17,659 in 1970 to 396,145 in 2010.

Figure 1: Registration of IPRs in the Republic of Korea



Source: Drawn using the data from https://www.kipo.go.kr.

B. Empirical Research on Diverse Intellectual Property Right Forms: Patents, Utility Models, and Trademarks

The shift from research on the strength of IPRs to that which identifies the role of diverse IPRs can be seen in Kim et al. (2012) with utility models and in Kang et al. (2019) with trademark lectures.

registering patents in KIPO.

Kim et al. (2012) exploit country- and firm-level data to extend empirical research on the effects of intellectual property protection on innovation and economic growth by focusing on the relative role of two types of protection; namely, patents and utility models. The results from both datasets are complementary. First, controlling for other variables, differences in economic growth and innovation can be explained by variations in patent rights, but not by those in the provision of utility models in high-income economies. In middle-income to low-income countries, the reverse is the case; that is, utility models help make a developing country build its technological capacity. Incremental, adaptive R&D leads to innovations that qualify for such utility model protection and provides a foundation upon which to eventually produce patentable innovations. These results suggest that the key issue for developing countries is not the strong or weak intellectual property protection, but rather having the appropriate kind of intellectual property protection. However, this point is relatively neglected in current policy debates and in previous research. Correspondingly, in the Korean firm-level data, patentable innovations positively and significantly matter to firm growth, whereas utility model innovations are insignificant when firms are technologically advanced. During the period when Korean firms were still technologically lagging (i.e., 1970–1986), incremental innovations have a positive impact on firm performance, controlling for other variables. However, patents do not have a statistically significant effect. Thus, this finding strongly supports the view that utility models are a good strategy for a latecomer's growth, particularly at its early stages. However, for the period 1987–1995, when the ROK had acquired greater technological and R&D capabilities, patents considerably and positively explain sales growth, whereas utility model applications do not. By the time considerable technological competence is achieved, a role reversal occurs in that a firm relies less on minor innovations for its performance and more on inventive, patentable innovations. Moreover, utility model innovations can serve as

an important input into the generation of future patentable innovations.

Kang et al. (2019) show that dynamic changes in leading industries were reflected in applications for different types of IPR, with utility models and trademarks filed mostly in light manufacturing sectors until the 1980s. Faced with challenges caused by macroeconomic factors (such as rising wage rates) and changing competitive landscapes (with the rise of new rivals), Korean firms turned their attention to developing technological capabilities, especially in information and communication technology (ICT) industries from the mid-1980s. Corporate in-house R&D centers started to mushroom, and private and public R&D expenditure steeply increased. Entering globalization, Korean industries departed from the previous model of catch-up based on imitative technologies and embarked on innovation-based catch-up. This structural transformation was fully reflected in the transition from the early dominance of utility models and trademarks to the later dominance of patents in aggregate and in certain sectors. Moreover, an interesting division between patent-dominated and trademark-dominated sectors was observed. The former included electronics, ICT, machinery, and automobile sectors, whereas the latter included the light manufacturing (leather, food, and apparel) and pharmaceutical industries. This pattern is even more visible with firm-level IPR statistics. That is, trademark domination tends to reflect the nature of knowledge (such as high degree of tacitness) and the initially low or slow development of technological capabilities in the concerned sectors, such as pharmaceuticals, that have focused on domestic market-oriented business rather than exports.

C. Economic Development and Design

Design or industrial design as defined by the World Intellectual Property Organization (WIPO) constitutes the ornamental or aesthetic aspects of an article. Design is defined as "the shape, pattern,

color, or any combination thereof in an article, which produces an aesthetic impression on the sense of sight." Design has been identified as an important means to add value to products and services and improve competitiveness (Rothwell and Gardiner 1983). Designs increase a product's attractiveness and appeal to add commercial value and increase its marketability. Design has also been used as a means of communicating with customers through products (Verganti 2009), and is thus an important activity for manufacturing firms and an important subject for economics; design management is a vital aspect of corporate strategy (Walsh 1996). In addition, design has been considered an important driver of innovation, acting as a bridge between technical and customer-oriented functions (Kline and Rosenberg 1986, Rothwell 1992, and Walsh 1996). The appropriate design of a user-friendly feature may satisfy customers. Similar to innovation, the results of design activity have the important potential to influence future economic growth (Moultrie et al. 2008). At times, design and quality do not necessarily match, but the uniqueness of the appearance could increase purchasing power and result in profit.

Product differentiation is achieved through design; moreover, technology gaps can be overcome by design. The relationship between the national economy and design can be discussed in relation to the stage of development of the national industrial strategy. Design is not important when the national economy is underdeveloped because the growth engine relies on the mass production of low-cost goods with low wages. However, the proportion of design increases as the economic structure advances. International competitiveness can be maintained only through product differentiation and high quality through technological innovation and design development. In the ROK, the 5-year plan to foster industrial design has been continuously pursued since 1993, and the Government of the ROK attempts to raise investments in design to the level of technology.

Industrial design is one field that receives much support from the national level because of its direct relation to the competitiveness of export products. Recently, to promote exports, the Ministry of Trade, Industry, and Energy; the Ministry of Economy and Finance; and the Ministry of Small-Medium Enterprises and Startups began to emphasize the importance of design and cultural storytelling.[4]

In the ROK, examples of the relationship between product competitiveness and industrial design can be seen in electronics, rubber, and plastic industries.

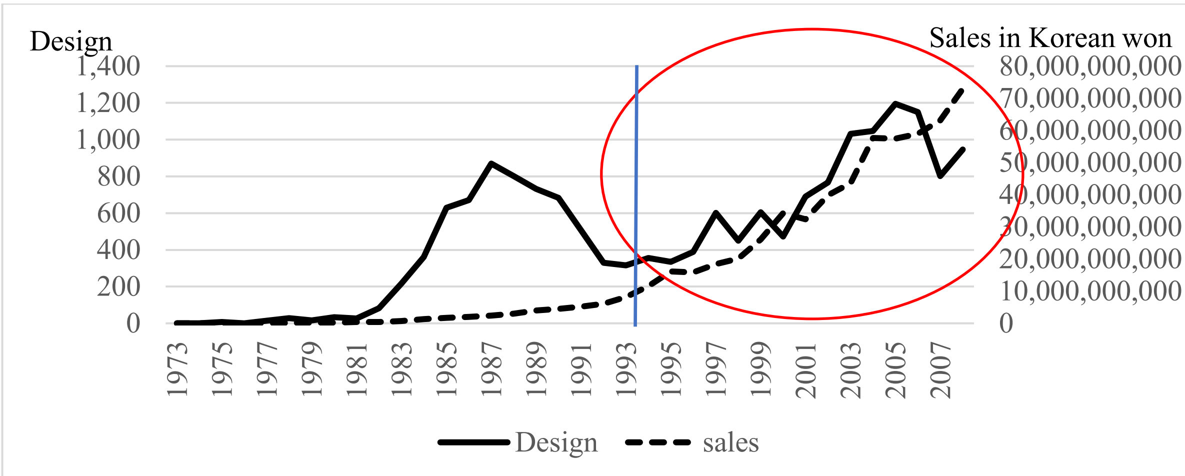
Samsung Electronics,[5] the largest chaebol founded in 1969, promoted its design center, Samsung Design, from a small group to a company-wide R&D organization in 1981. The renowned "new management initiative" was declared in 1993. Kun-Hee Lee, the Samsung chairperson, announced a complete renovation of Samsung via "The Frankfurt Declaration (New Management Initiative)." He pointed out that good design is a critically lacking element in Samsung's products to excel in world markets. Samsung declared 1996 as the "year of design revolution" to build a unique design identity. From that time, Samsung grew to become a global brand. Figure 2 shows a similar trend between design registration and the total sales of Samsung since 1993. Figure 3 shows that Samsung's exports are much higher than domestic sales after 1996.

---

[4] http://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=4697.

[5] http://www.design.samsung.com/global/contents/design-history/index.html.

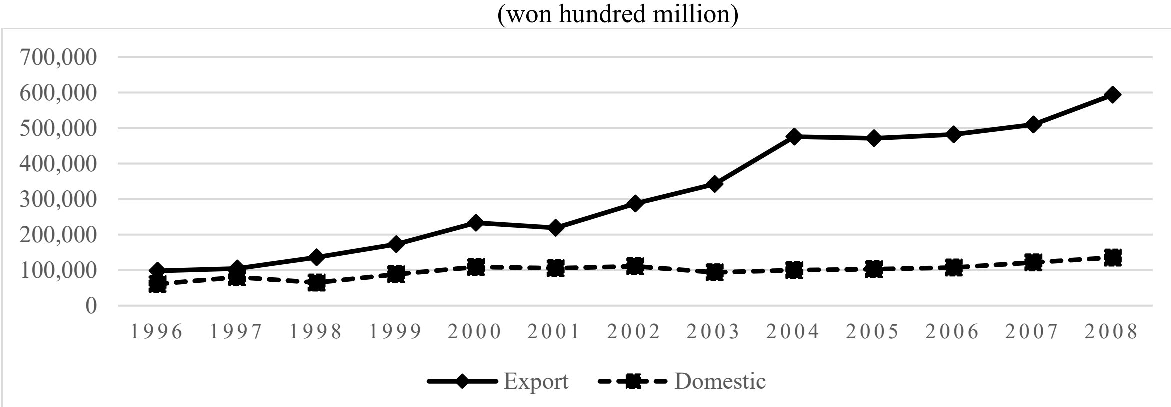
Figure 2: Design Registration and Sales Growth of Samsung



Source: Authors' data.

Figure 3: Samsung's Export versus Domestic Sales

(won hundred million)



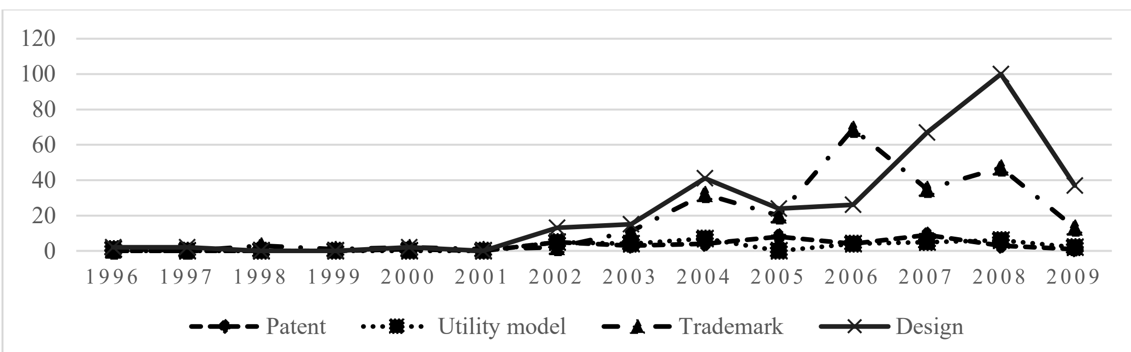
Source: Drawn using the data from http://dart.fss.or.kr/.

Recently, design became a widely known topic after Apple sued Samsung for alleged copying of Apple phone designs rather than regular patents, and after Samsung Electronics received 55 prizes in the International Forum Design Award in 2018.

LocknLock, a small and medium-sized enterprise in the rubber and plastic sector founded in 1978, aims to be the number 1 company that offers comprehensive household products that the world can trust with its finest quality and international competitiveness. After failing in original

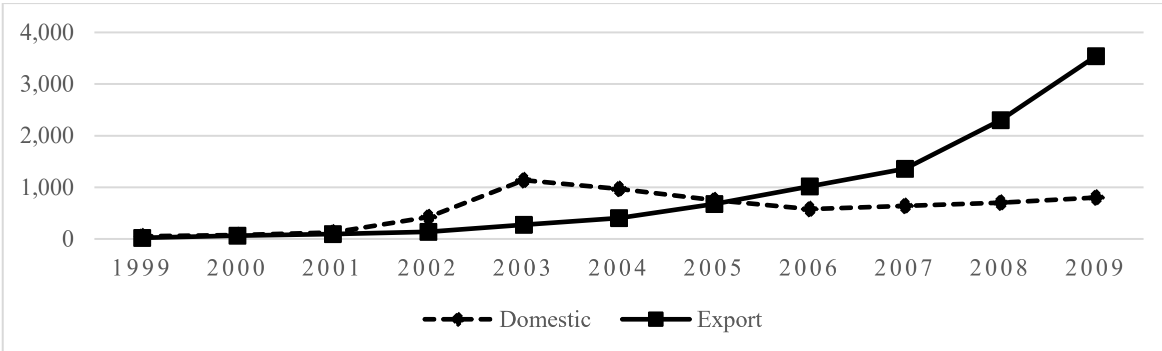
enterprise manufacturing, LocknLock abandoned its old items, produced new ones, and pursued its own branding strategy (Lee et al. 2015). The unique design with a four-sided sealed container led to their success. With original designs based on quality, LocknLock entered the United States home shopping market and achieved great results in exports (Lee et al. 2008). Design has been its leading IPR since 2000 (Figure 4), overtaking leading international brands from developed countries operating in the Korean market (e.g., Tupperware) and has become a successful player in the global market. Figure 5 shows that the export of LocknLock surpassed domestic sales since 2005. This firm also won prizes at the Red Dot Design Awards in 2008 and 2011 and the International Forum Design Awards in 2018.

Figure 4: Registration of Four Intellectual Property Rightss in the Case of a Small and Medium-Sized Enterprise, LocknLock



Source: Authors' data.

Figure 5: Sales Growth of LocknLock; Domestic versus Export
(won hundred million)



Source: Drawn using the data from https://news.naver.com/main/read.nhn?oid=009&aid=0002084305.

In general, design is analyzed quantitatively from the perspectives of art, management, or thinking with the use of survey data (Ahire and Dreyfus 2000 and Delmastro et al. 2012). Chiva and Alegre (2009) analyze design investment and firm performance with a survey of 182 Italian and Spanish ceramic tile company managers and find that design management enhances firm performance. Survey analysis of the performance of design business supported by the Government of the ROK shows that long business experience, large firm size, and economic performances are positively related to government design support (Lee and Lee 2008). Bidirici and Bohur (2015) analyze the relationship of design and firm performance using a panel cointegration test and Granger causality methods with large firms in Turkey. The study concludes that firms should head design for the continuous growth of the Turkish industry and to create more value. A study conducted in the United Kingdom using regression analysis on the relation of productivity and holding designs in the Office for Harmonization in the Internal Market (OHIM) and/or the UK Intellectual Property Office (UKIPO) concludes that registered designs cause symptomatic differences in performance from 2004 to 2010 (UKIPO 2011). However, no existing study uses regression analysis on design registration and firm performance on a registered design with long-

term panel data, which is the objective of this present study.

III. SECTOR LEVEL ANALYSIS: WHICH SECTOR TENDS TO FILE MORE DESIGNS?

This section first analyzes the issue of which sector tends to file more designs. The registration pattern of design is not apparent, such as in patents or trademarks. Thus, we consider the design data for selecting the design sector using diverse criteria: (i) total number of registered design, (ii) number of design per firm in the sector, (iii) total number of design of the sector/total number of IPRs of the sector, and (iv) annual average growth of design registration of the sector. With these criteria, Table 1 lists the design-intensive sectors.

Table 1: Identification of Design-Intensive Sectors (1971–2010), by Criteria

Rank	Number of Registered Design	Number of Design per Firm	Number of Design/Total Number of IPRs	Annual Average Growth of Design Registration
1	Electronics (49,186)	Electronics (6.25)	Fabricated metals (44%)	Rubber and plastics (7.7%)
2	Chemicals (20,920)	Rubber and plastics (3.32)	Rubber and plastics (39%)	Food (4.0%)
3	Automobile (18,545)	Food (2.88)	Consumer goods (35%)	Electronics (3.4%)
4	Food (13,982)	Chemicals (2.81)	Paper (34%)	Electrical machinery (3.1%)
5	Machinery (9,106)	Automobile (1.96)	Electronics (27%)	Machinery (2.7%)
6	Rubber and plastics (8,048)	Consumer goods (1.65)	Chemicals (23%)	Consumer goods (1.8%)
7	Electrical machinery (6,711)	Apparel (1.33)	Machinery (22%)	Chemicals (1.6%)
8	Fabricated metals (6,459)	Fabricated metals (1.25)	Automobile (21%)	Automobile (1.53%)
9	Consumer goods (4,063)	Electrical machinery (1.06)	Electrical machinery (20%)	Fabricated metals (1.51%)
10	Non-metallic minerals (3,695)	Machinery (1.02)	Food (19%)	Computer (1.4%)

Source: Authors' data.

According to the four criteria, nine of 22 sectors are selected as design-intensive sectors: electronics, chemicals, automobile, food, machinery, rubber and plastics, electrical machinery,

fabricated metals, and consumer goods. The other 13 are categorized as low-design sectors. In comparing the high-design and low-design sectors, we choose variables to explain the sector characteristics, such as export propensity. T-tests were conducted using these variables.

Table 2: Description of Variables

Variable	Description
Export dummy 1	1 if the sector's export share is over the average of export shares in all manufacturing years
Export dummy 2	1 if the export dummy1 lasts more than 20 years
Explicit of knowledge	Number of patents registered/R&D expenditure
R&D intensity	Total R&D of firms/total sales of firms
Advertisement intensity	Total advertising cost of firms in each sector/sales in each sector
Capital labor ratio	Fixed asset of firms in each sector excluding estate/no. of employees in each sector

R&D = research and development.
Source: Authors' data.

Table 3: High Design-Intensity Sector versus Low Design-Intensity Sector

Variable	High Design Sector		Low Design Sector		T-test	
	Mean	Standard Deviation	Mean	Standard Deviation	t	p-value
Patent	309.783	1302.739	18.014	70.309	5.265	0.000***
Trademark	63.474	131.377	87.616	290.123	−1.375	0.085*
Utility model	289.339	1777.920	12.326	74.297	3.667	0.000***
Design	84.053	262.229	10.362	19.587	6.590	0.000***
Employees	21584.070	96773.110	7671.443	37295.820	3.005	0.001***
Explicit knowledge	0.003	0.029	0.000	0.004	2.165	0.015**
Export dummy 1	0.530	0.500	0.303	0.460	6.703	0.001***
Export dummy 2	0.750	0.434	0.611	0.488	4.155	0.000***
Advertisement intensity	0.007	0.015	0.012	0.021	−3.496	0.000***
Research and developmemt intensity	0.009	0.011	0.006	0.026	1.699	0.044**
Capital labor ratio	150.296	164.407	193.700	337.550	−1.964	0.025**

Source: Authors' data.

From the test, firms in design-intensive sectors are those with large sizes, which conduct more

R&D and export, but less advertising. Moreover, the knowledge characteristics are more explicit, unlike in the cases of the trademark-driven sectors in Kang et al. (2019). Among these variables, we focus on export as the explanatory variable of the design sector. As competition for technology development and global trade wars intensifies, the role of design in the development of new products changes. The product's value is enhanced by a beautiful and sophisticated design that leads consumers' emotions. The increase in exports because of the addition of design is observed not only in the ROK but also globally. Thus, we set the first hypothesis as follows:

Hypothesis 1:

A high design-intensive sector tends to be a high export-oriented sector.

To analyze the relationship between design registration and export in the Korean manufacturing sector, we use the sector-level data of the ROK covering 1971‒2010. All four forms of IPR data are downloaded from the Korea Intellectual Property Rights Information System (KIPRIS). The financial data on Korean external auditing or listed companies is built using the financial database of the Center for Economic Catch-up for the data period to 1979 and the Korea Information Service from 1980–2010. Given that both firm-level IPR data and financial data are downloadable, we modify the sector-level variable as the total sum of firm-level data in each sector. We use the Eighth Korean Standard Industrial Classification (KSIC). The tobacco (D16) and the recycling (D37) sectors are excluded because these do not fit in the analysis. After matching IPR and financial data by corporation code, we build a panel data with 22 sectors classified by the KSIC three-digit industry code. The period covered is divided into three sub-periods, 1971‒1986,

1987–1998, and 1999–2010, which are chosen by reference to important episodes in modern Korean economic history. Since the mid-1980s, the ROK has emphasized in-house R&D in private sectors, and considerable public–private joint R&D has been established to conduct R&D projects (Lee 2013). From 1987, the patent law was considerably revised, including that of substance patent. Following the division of Kim et al. (2012), we choose 1986 as the first division of the three periods. The second division ends in the year after the 1997 Asian financial crisis. With the huge impact of this crisis, its selection for dividing the latter period is inevitable.

The main explanatory variable is the export dummy. Given that the entire sector is divided as the design group and the less-design group, our concern is on the relationship between the design group and exports. All IPR numbers constitute the sector's mean value. The variable explicitness of knowledge originated from Jung and Lee (2010), using patent registration data and the amount of R&D investment of each year. Including explicitness, the model is set with other variables to identify the determinants of total factor productivity catch-up by Korean firms compared with that of Japanese firms from the perspective of sectoral systems of innovation. This measure of explicit knowledge is built on the concept that more patent applications per unit of R&D expenditure correspond to higher explicitness across sectors. Meanwhile, tacitness is the contrary concept of explicitness (Jung and Lee 2010). [6]

---

[6] This idea of defining explicitness is based on Gonzalez and Mariano's (2007) findings. They explain that firms that mainly use explicit knowledge choose the patenting system as a protection method, whereas those that rely more on tacit knowledge are inclined to remain private rather than use the patent. This measure of knowledge explicitness is built on the concept that more patent applications per unit of R&D expenditure corresponds to higher explicitness across sectors, and tacitness is a contrary concept of explicitness (Jung and Lee 2010).

Table 4: Correlation of Variables

	Design Group	Export Dummy 1	Export Dummy 2	Capital Labor Ratio	R&D Intensity	Advertisement Intensity	Explicit Knowledge
Design group	1						
Export dummy 1	0.1598	1					
Export dummy 2	0.063	0.3651	1				
Capital labor ratio	−0.103	−0.0266	0.0216	1			
R&D intensity	0.0823	0.1177	0.0706	−0.0385	1		
Advertisement intensity	−0.0579	−0.2294	−0.3103	−0.1503	−0.0076	1	
Explicit knowledge	−0.0479	−0.0535	−0.0509	−0.0244	−0.031	−0.0192	1

R&D = research and development.
Source: Authors' data.

Our main purpose is to verify the relationship between the design group and export variable. For this analysis, we estimate a probit model appropriate for a qualitative binary dependent variable. The probit regression is typically applied to predict probability values of a two-sided test in parentheses. In our analysis, the value of the design dummy is fixed as 1 if the sector is the design group, and 0 if the sector is the less design group regardless of the year. Thus, we estimate the result as a pooled probit regression model.

$$Design\ dummy = \beta_0 + \beta_1 export\_dummy1_{or}2 + \beta_2(Knowledge\ explicitness_{t-1}) + \beta_3(Advertisement\_intensity_{t-1}) + \beta_4(Capital\_labor\_ratio_{t-1.}) + \beta_5(R\&D\_intensity_{t-1.}) + \varepsilon.$$

Given that the export-oriented sector changes according to economic development, we use two types of export dummy. *Export-dummy1* may be changed yearly to 0 if the sector's export share is under the mean of all those in the manufacturing sector, whereas *Export-dummy2* is prefixed by the definition. [7]

Table 5 presents the results of the pooled probit regression.

Table 5: Pooled Probit Regression

Variables	Model (1) Pooled Probit	Model (2) Pooled Probit	Model (3) Pooled Probit
Export dummy 1	0.400***		
	(3.890)		
Export dummy 2		0.218**	
		(2.013)	
Capital labor ratio (t−1)	−0.000**	−0.001**	−0.001**
	(−2.100)	(−2.279)	(−2.278)
Research and development intensity	7.783	10.121*	11.654**
	(1.434)	(1.897)	(2.215)
Advertisement intensity	−1.011	−2.105	−3.490
	(−0.366)	(−0.751)	(−1.296)
Explicit knowledge	−0.070	−0.059	−0.057
	(−0.688)	(−0.609)	(−0.582)
Period 2	0.009	−0.003	0.014
	(0.072)	(−0.025)	(0.105)
Period 3	0.036	0.027	0.036
	(0.280)	(0.213)	(0.281)
Constant	−0.479***	−0.448***	−0.301***
	(−4.376)	(−3.634)	(−3.044)
Observations	715	715	715
ind3 Dummy	Yes	Yes	Yes

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' calculations.

The dependent variable is the design group dummy, which is fixed to high design sectors.

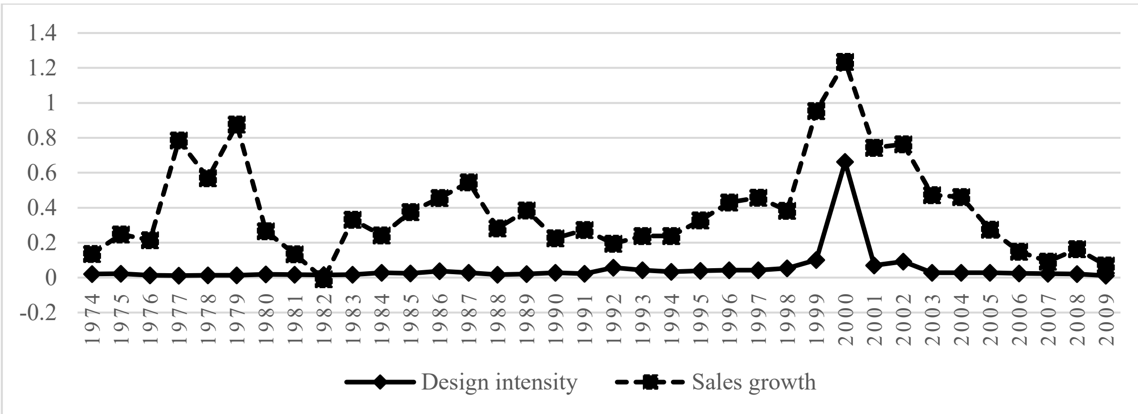
[7] If the export dummy1 lasts more than 20 years.

Regression without an export dummy is also conducted to check the effect on other variables. The results are nearly similar regardless of the variable. Given that the design group dummy represents design sectors, we assume that the export dummy is positively related to design sectors. The probit regression result shows that both types of export dummies have a positively significant relationship with design group. Thus, H1 is accepted.

IV. FIRM-LEVEL ANALYSIS: DESIGN INTENSITY AND FIRM PERFORMANCE

As the technology matures and the development cost declines, firms depend on distinctive design more than before, and the number of firms that pay attention to creative design increases. In the post-catch-up period, international competitiveness can be maintained through product differentiation, and high quality through technological innovation and design development (Cho 2004). Design is closely related to technological capability; saying that the level of technology influences the level of design is not an exaggeration. The increasing gross domestic product per capita and attention to design are highly correlated by the growth of the design industry in Japan, which the gross national product surpassed $10,000 from 1982 (Chung 2003). Thus, design becomes increasingly important in the advanced stages. In the ROK, design has been emphasized since the mid-1990s when gross domestic product reached $10,000 for the first time (Chung 2003). That is, designs have not increased much in the earlier stage.

Figure 6: Design Intensity and Sales Growth



Source: Authors' data.

Figure 6 shows that design intensity is almost 0 in the entire period except in 2000-2009, and sales growth also peaked at the same time. From this trend, we assume that design intensity may affect firm performance in the later stage. Thus, we set the second hypothesis as follows:

Hypothesis 2

High design intensity positively affects the sales growth of firms at the later stage of development.

For the analysis of firm performance and IPR registration, we use the firm-level panel data of manufacturing sectors from the ROK covering 1971–2010. Patent, utility model, trademark, and design data are downloaded from KIPRIS (www.kipris.or.kr). The total number of raw IPR data is 2,319,102 patents and 1,006,645 designs. The manufacturing sector includes 7,094 external audited firms. To build the financial data on the ROK external auditing or listed companies, we

use the financial database of the Center for Economic Catch-up[8] until 1979, and the Korea Information Service Value from 1980 to 2010. The period division is the same as the sector analysis.

Table 6: Description of Variables

Variable	Description	Obs	Mean	Std. Dev.
Sales growth (performance)	Sale (t)-sales (t−1)/sales (t−1)	85189	0.4079279	2.885506
Patent intensity	Number of patent registration of the firm in each year/sales (won billion) of the firm in each year	92574	0.0959413	2.991162
Design intensity	Number of design registration of the firm in each year/sales (won billion) of the firm in each year	92574	0.0709873	5.264944
Firm age	Current year - foundation year	97947	14.67546	1.22E+01
R&D intensity	R&D expenses (t)/sales (t)	60181	1585439	4.46E+07
Employees (firm size)	Total number of employees of the year	88934	502.8251	18083.47
Advertisement intensity	Advertisement cost (t)/sales (t)	83145	1055135	2.05E+07

R&D = research and development.
Source: Authors' data.

Table 7: Correlation of Variables
(whole data)

	Sales Growth	Patent Intensity	Design Intensity	Firm Age	R&D Intensity	Employees	Advertisement Intensity
Sales growth	1						
Patent intensity	0.0517	1					
Design intensity	−0.0016	0.0038	1				
Firm age	−0.1194	−0.0542	−0.0078	1			
R&D intensity	−0.0019	0.0017	−0.0002	0.0416	1		
Employees	−0.0047	−0.0021	−0.0005	0.0433	0.1428	1	
Advertisement intensity	−0.0049	−0.0008	−0.0003	0.0757	0.7725	0.1665	1

R&D = research and development.
Source: Authors' data.

[8] The financial data of the 1970s was only in printed document; thus, researchers and students of the Center for Economic Catch-up built financial data of the 1970s manually in 2007. The data have been extensively utilized in the analysis of firm performance of the 1970s.

Table 8: Correlation of Variables
(high design group)

	Sales Growth	Patent Intensity	Design Intensity	Firm Age	R&D Intensity	Employees	Advertisement Intensity
Sales growth	1						
Patent intensity	0.036	1.000					
Design intensity	−0.002	0.002	1				
Firm age	−0.128	−0.080	−0.010	1.000			
R&D intensity	−0.003	0.006	0.000	0.053	1.000		
Employees	−0.004	−0.001	−0.001	0.043	0.158	1.000	
Advertisement intensity	−0.005	0.001	0.000	0.084	0.779	0.185	1

R&D = research and development.
Source: Authors' data.

Table 9: Correlation of Variables
(low design group)

	Sales Growth	Patent Intensity	Design Intensity	Firm Age	R&D Intensity	Employees	Advertisement Intensity
Sales growth	1						
Patent intensity	0.0741	1					
Design intensity	0.0045	0.0519	1				
Firm age	−0.1113	−0.0528	−0.0235	1			
R&D intensity	−0.0065	−0.0005	−0.0044	0.1281	1		
Employees	−0.0062	−0.0041	−0.0024	0.0518	0.1135	1	
Advertisement intensity	−0.0148	−0.008	0	0.1951	0.3671	0.0862	1

R&D = research and development.
Source: Authors' data.

To verify the effects of IPRs on each group and period, we run the fixed effect regression and system generalized method of moments (GMM) with 1-year lagged variables to examine the relationship between IPRs and firm performance in consideration of the time lag. A full set of year dummies is included to account for the time-dependent overall effects in markets. Full sets of industry dummies are also included to capture industry-specific variations.

$$Performance_{i,t} = \beta_0 + + \beta_1 Performance_{i,t-1} \;\; + \beta_2 Design\ intensity_{i,t-1} +$$

$\beta_3 Patent\ intensity_{i,t-1} + \ \beta_4 (Design\ intensity_{i,t-1} *$

$Patent\ intensity_{i,t-1}) + \ \alpha_1 Advertisement\ Ratio_{i,t-1} + \alpha_2 R\&D\ intensity_{i,t-1} +$

$\alpha_3 Employees_{i,t-1} + \ \alpha_4 Age_{i,t} + \varepsilon_{it}$

We analyze the effect of IPR registration on firm performance with IPR intensity in each period. Although we have two groups, we analyze the entire sector to confirm the periodical different influence of IPR registration on firm performance. Table 10 shows the results. Patent and design intensities positively affect firm performance only in the third period.

Table 11 presents the regression results of high design-intensive sector. In the entire period, patent and design positively affect firm performance, except in Period 1. In Period 2, only design intensity is significant on firm performance. The interaction effect between patent and design is also significant in this period. That is, design is more important than patents in Period 2. In Period 3, both design and patent are significant for firm performance, and the no interaction term is significant.

In the low design sector, design alone is not significant and is only significant when patent-design interaction term is presented in the model. In this model, the registration of design and patent in Period 3 positively affects firm performance, and the no interaction term is significant. Table 12 presents the results.

Table 10: Design Intensity for Firm Growth: All Sectors

Variables	Period 1 (1971–1986) FE	Period 1 (1971–1986) SYS.GMM	Period 1 (1971–1986) FE	Period 1 (1971–1986) SYS.GMM	Period 2 (1987–1998) FE	Period 2 (1987–1998) SYS.GMM	Period 2 (1987–1998) FE	Period 2 (1987–1998) SYS.GMM	Period 3 (1999–2010) FE	Period 3 (1999–2010) SYS.GMM	Period 3 (1999–2010) FE	Period 3 (1999–2010) SYS.GMM
Sales growth(t-1)	-0.231***	-0.173***	-0.231***	-0.172***	-0.056***	0.027*	-0.056***	0.027*	-0.087***	0.016	-0.087***	0.016
	(-8.691)	(-2.926)	(-8.695)	(-2.953)	(-9.648)	(1.935)	(-9.633)	(1.852)	(-25.312)	(1.519)	(-25.274)	(1.528)
Sales growth(t-2)	-0.038***	-0.030**	-0.038***	-0.030**	-0.025***	-0.003	-0.024***	-0.002	-0.021***	-0.002	-0.021***	-0.002
	(-3.694)	(-2.036)	(-3.704)	(-2.022)	(-7.921)	(-1.264)	(-7.782)	(-1.043)	(-11.679)	(-0.813)	(-11.643)	(-0.827)
Design intensity(t-1)	-0.402	-1.108	-0.120	-0.713	5.103***	1.909	5.338***	2.115	0.634***	0.627***	0.684***	0.547**
	(-0.580)	(-1.068)	(-0.163)	(-0.654)	(56.155)	(1.029)	(57.614)	(1.030)	(9.693)	(2.747)	(9.385)	(2.406)
Patent intensity(t-1)	10.427***	7.823	11.688***	8.931	0.504***	0.407	1.095***	0.743	1.365***	0.992***	1.381***	0.956***
	(3.715)	(1.291)	(3.874)	(1.249)	(3.212)	(0.720)	(6.675)	(1.246)	(26.927)	(4.243)	(26.661)	(3.987)
Design intensity(t-1) * Patent intensity(t-1)			-28.096	-25.481			-13.452***	-6.084			-0.284	0.593
			(-1.139)	(-1.054)			(-11.557)	(-0.819)			(-1.554)	(0.967)
Export sector dummy	0.053***	0.049	0.053***	0.049	0.007	0.015***	0.007	0.015***	0.020***	0.018***	0.020***	0.018***
	(3.543)	(1.266)	(3.552)	(1.243)	(1.528)	(2.886)	(1.539)	(2.823)	(4.835)	(2.977)	(4.844)	(2.969)
Employees(t-1)	-0.160***	-0.109	-0.160***	-0.107	-0.208***	-0.291***	-0.204***	-0.284***	-0.201***	-0.160***	-0.201***	-0.160***
	(-2.955)	(-0.661)	(-2.947)	(-0.667)	(-10.781)	(-3.870)	(-10.666)	(-3.871)	(-15.081)	(-3.020)	(-15.100)	(-3.013)
Firm age(t-1)	-0.432	-1.026	-0.440	-1.052	-0.337***	-0.052	-0.333***	-0.036	-0.569***	-0.414**	-0.569***	-0.411**
	(-1.183)	(-0.813)	(-1.204)	(-0.827)	(-6.435)	(-0.411)	(-6.396)	(-0.252)	(-14.575)	(-2.495)	(-14.572)	(-2.472)
Advertisement ratio(t-1)	0.113***	0.145	0.112***	0.145	0.022***	0.019***	0.021***	0.018***	0.045***	0.065***	0.045***	0.065***
	(3.385)	(0.912)	(3.362)	(0.919)	(3.563)	(3.572)	(3.504)	(3.347)	(10.343)	(6.835)	(10.332)	(6.850)
R&D intensity(t-1)	0.010***	0.013***	0.011***	0.013***	0.004***	0.003***	0.004***	0.004***	0.003***	0.003***	0.003***	0.003***
	(2.951)	(2.929)	(2.962)	(3.004)	(3.518)	(3.583)	(3.525)	(3.478)	(3.062)	(2.874)	(3.045)	(2.893)
Constant	3.065***	7.089	3.070***	7.055	2.225***	2.990	2.190***	2.839	3.014***	0.082	3.013***	0.131
	(3.183)	(0.637)	(3.189)	(0.654)	(14.180)	(0.954)	(14.032)	(0.951)	(23.725)	(0.018)	(23.720)	(0.029)
Observations	1,880	1,880	1,880	1,880	15,093	15,093	15,093	15,093	38,177	38,177	38,177	38,177
R-squared	0.182		0.183		0.238		0.246		0.074		0.074	
Hausman test	132.59		38.07		9407.4		323.28		1592.64		1502.35	
AR2		0.8408		0.5805		0.376		0.2003		0.9032		0.8227
Number of firms	634	634	634	634	2,653	2,653	2,653	2,653	5,892	5,892	5,892	5,892

t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1
FE = fixed effects, SYS-GMM = system generalized method of moments.

Source: Authors' calculations.

Table 11: Design Intensity for Form Growth: Design-Intensive Sector

Variables	Period 1 (1971–1986) FE	Period 1 (1971–1986) SYS.GMM	Period 1 (1971–1986) FE	Period 1 (1971–1986) SYS.GMM	Period 2 (1987–1998) FE	Period 2 (1987–1998) SYS.GMM	Period 2 (1987–1998) FE	Period 2 (1987–1998) SYS.GMM	Period 3 (1999–2010) FE	Period 3 (1999–2010) SYS.GMM	Period 3 (1999–2010) FE	Period 3 (1999–2010) SYS.GMM
Sales growth(t-1)	-0.235***	-0.221**	-0.235***	-0.221**	-0.091***	0.021*	-0.090***	0.020*	-0.080***	0.010	-0.080***	0.010
	(-7.096)	(-2.267)	(-7.093)	(-2.266)	(-10.955)	(1.809)	(-10.973)	(1.759)	(-20.161)	(0.891)	(-20.131)	(0.908)
Sales growth(t-2)	-0.128***	-0.140	-0.128***	-0.140	-0.045***	-0.007	-0.043***	-0.006	-0.021***	-0.005*	-0.021***	-0.005*
	(-4.644)	(-1.503)	(-4.643)	(-1.501)	(-8.896)	(-1.191)	(-8.618)	(-1.307)	(-9.321)	(-1.803)	(-9.290)	(-1.800)
Design intensity(t-1)	0.120	0.083	0.176	0.236	6.276***	2.217*	6.702***	2.780*	0.907***	0.745**	0.954***	0.629*
	(0.191)	(0.079)	(0.260)	(0.166)	(52.969)	(1.760)	(55.395)	(1.726)	(10.881)	(2.311)	(10.209)	(1.936)
Patent intensity(t-1)	-0.727	-1.265	-0.471	-0.867	0.796***	0.336	1.678***	0.929	1.373***	1.125***	1.390***	1.075***
	(-0.275)	(-0.632)	(-0.163)	(-0.347)	(4.054)	(0.423)	(8.224)	(0.980)	(20.457)	(4.060)	(20.242)	(3.747)
Design intensity(t-1) * Patent intensity(t-1)			-4.348	-3.122			6.181**	4.332*			0.087	1.427
			(-0.223)	(-0.167)			(2.015)	(1.835)			(0.363)	(1.185)
Export sector dummy	0.028	0.055**	0.028	0.055**	0.002	0.016*	0.002	0.015*	0.020***	0.016*	0.020***	0.015*
	(1.306)	(2.429)	(1.309)	(2.407)	(0.262)	(1.883)	(0.257)	(1.854)	(3.328)	(1.840)	(3.339)	(1.780)
Employees(t-1)	-0.270***	-0.125	-0.270***	-0.123	-0.258***	-0.318***	-0.254***	-0.308***	-0.266***	-0.220***	-0.266***	-0.218***
	(-4.610)	(-0.932)	(-4.603)	(-0.910)	(-8.698)	(-3.733)	(-8.663)	(-3.548)	(-14.729)	(-2.662)	(-14.744)	(-2.619)
Firm age(t-1)	-1.946***	-1.196	-1.948***	-1.201	-0.503***	-0.103	-0.502***	-0.088	-0.538***	-0.446***	-0.537***	-0.453***
	(-5.487)	(-1.100)	(-5.487)	(-1.104)	(-6.351)	(-0.719)	(-6.412)	(-0.556)	(-10.431)	(-2.754)	(-10.423)	(-2.828)
Advertisement ratio(t-1)	0.151***	0.103	0.151***	0.103	0.018**	0.018**	0.019**	0.017**	0.050***	0.065***	0.050***	0.066***
	(3.977)	(1.252)	(3.969)	(1.264)	(1.972)	(2.529)	(2.058)	(2.398)	(8.942)	(5.915)	(8.931)	(5.913)
Research and development intensity(t-1)	0.011***	0.009**	0.011***	0.009**	0.005***	0.003***	0.005***	0.003***	0.004***	0.004***	0.004***	0.004***
	(3.020)	(2.553)	(3.020)	(2.556)	(2.810)	(2.695)	(2.767)	(2.795)	(2.928)	(3.233)	(2.915)	(3.283)
Constant	7.709***	6.454	7.710***	6.442	2.966***	2.181	2.947***	2.255	3.033***	1.002	3.031***	1.128
	(8.381)	(1.200)	(8.377)	(1.190)	(11.660)	(0.764)	(11.732)	(1.078)	(17.754)	(0.490)	(17.743)	(0.548)
Observations	1,059	1,059	1,059	1,059	9,195	9,195	9,195	9,195	25,226	25,226	25,226	25,226
R-squared	0.255		0.255		0.315		0.332		0.077		0.077	
Hausman test	144.9		9.74		13567.59		262.86		1107.3		1076.56	
AR2		0.4206		0.5631		0.7508		0.8552		0.2243		0.1205
Number of firms	347	347	347	347	1,695	1,695	1,695	1,695	3,949	3,949	3,949	3,949

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

FE = fixed effects, SYS-GMM = system generalized method of moments.
Source: Authors' calculations.

Table 12: Design Intensity for Form Growth: Low Design Sector

Variables	Period 1 (1971–1986) FE	SYS.GMM	Period 1 (1971–1986) FE	SYS.GMM	Period 2 (1987–1998) FE	SYS.GMM	Period 2 (1987–1998) FE	SYS.GMM	Period 3 (1999–2010) FE	SYS.GMM	Period 3 (1999–2010) FE	SYS.GMM
Sales growth(t-1)	-0.284***	-0.185*	-0.284***	-0.185*	0.018***	0.026*	0.018***	0.026*	-0.132***	0.011	-0.132***	0.012
	(-6.796)	(-1.936)	(-6.793)	(-1.919)	(3.247)	(1.869)	(3.241)	(1.868)	(-16.686)	(0.450)	(-16.623)	(0.470)
Sales growth(t-2)	-0.030**	-0.019	-0.029**	-0.019	-0.005**	-0.003	-0.005**	-0.003	-0.022***	-0.001	-0.022***	-0.001
	(-2.278)	(-1.478)	(-2.272)	(-1.486)	(-1.968)	(-1.337)	(-1.966)	(-1.356)	(-6.997)	(-0.159)	(-6.995)	(-0.114)
Design intensity(t-1)	-0.656	-0.990	-0.537	-0.908	-0.014	0.016	-0.042	-0.002	0.052	0.251**	0.236**	0.387***
	(-0.435)	(-1.074)	(-0.347)	(-1.118)	(-0.133)	(0.159)	(-0.377)	(-0.024)	(0.502)	(2.205)	(2.053)	(2.911)
Patent intensity(t-1)	27.639***	32.208**	28.513***	32.650**	0.015	0.106	0.017	0.137	1.365***	1.087***	1.404***	1.143***
	(4.887)	(2.354)	(4.591)	(2.173)	(0.093)	(0.481)	(0.095)	(0.535)	(18.876)	(3.141)	(18.958)	(3.268)
Design intensity(t-1) * Patent intensity(t-1)			-55.517	-65.609			1.035	0.533			-0.809**	-0.722
			(-0.342)	(-0.205)			(1.270)	(1.013)			(-2.447)	(-1.353)
Export sector dummy	0.067***	-0.003	0.067***	-0.003	0.023***	0.025***	0.023***	0.025***	0.009*	0.022***	0.009*	0.021***
	(2.956)	(-0.089)	(2.956)	(-0.090)	(4.699)	(2.750)	(4.713)	(2.739)	(1.720)	(2.938)	(1.703)	(2.948)
Employees(t-1)	-0.049	-0.094	-0.050	-0.087	-0.128***	-0.188***	-0.128***	-0.188***	-0.082***	-0.066**	-0.082***	-0.067**
	(-0.534)	(-0.500)	(-0.541)	(-0.450)	(-8.152)	(-3.318)	(-8.156)	(-3.324)	(-4.422)	(-1.970)	(-4.444)	(-2.009)
Firm age(t-1)	2.430***	0.440	2.442***	0.467	-0.182***	-0.133	-0.182***	-0.138	-0.624***	-0.631	-0.626***	-0.618
	(3.273)	(0.165)	(3.282)	(0.172)	(-4.152)	(-1.174)	(-4.166)	(-1.216)	(-10.979)	(-1.409)	(-11.002)	(-1.397)
Advertisement ratio(t-1)	0.040	0.114	0.040	0.113	0.028***	0.021***	0.028***	0.021***	0.031***	0.051***	0.031***	0.051***
	(0.749)	(0.933)	(0.740)	(0.883)	(5.730)	(2.685)	(5.750)	(2.695)	(4.678)	(3.230)	(4.680)	(3.272)
Research and development intensity(t-1)	0.008	0.006	0.008	0.006	0.003***	0.002**	0.003***	0.002**	0.002	-0.000	0.002	-0.000

	(1.214)	(0.981)	(1.192)	(0.998)	(3.029)	(2.336)	(3.049)	(2.337)	(1.176)	(-0.076)	(1.155)	(-0.056)
Constant	-5.415***	1.832	-5.446***	1.735	1.431***	2.159	1.434***	2.204	2.473***	-4.834	2.477***	-6.207
	(-2.695)	(0.082)	(-2.705)	(0.077)	(10.723)	(0.405)	(10.744)	(0.410)	(13.678)	(-0.109)	(13.704)	(-0.129)
Observations	821	821	821	821	5,898	5,898	5,898	5,898	12,951	12,951	12,951	12,951
R-squared	0.243		0.243		0.076		0.076		0.081		0.082	
Hausman test	72.27		79.46		3958.96		4163		527.08		740.45	
AR2		0.2038		0.2018		0.8366		0.7978		0.8099		0.9213
Number of firms	287	287	287	287	958	958	958	958	1,943	1,943	1,943	1,943

t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

FE = fixed effects, SYS-GMM = system generalized method of moments.

Source: Authors’ calculations.

V. SUMMARY AND CONCLUDING REMARKS

Taking advantage of the unique longitudinal data of IPRs at sector and firm levels in the ROK, this study conducts an empirical analysis of the roles of design in economic development and firm performance. Certain sectors are found to have different IPRs, such as designs, that produce considerable impact in different stages of development. In addition, designs tend to be filed by more export-oriented sectors at the later stage of development or since the late 1980s and 1990s onward in the case of the ROK.

The first research question in this study is which sector files more design. A design-intensive sector tends to be export-oriented and less capital-intensive. These sectoral characteristics differ from trademark-oriented sectors, which tend to be advertising-intensive but less R&D-intensive, and involving greater tacit knowledge. The second research question is about the impact of design on firm performance. The result of using firms from all sectors shows that design is significant for firms' sales growth only in Period 3 or 2000-2009. The results of using firms from design-intensive sectors show that design is significant since Period 2 and after or since the late 1980s and 1990s. In addition, patents are not significant in the early period or in Period 1 and Period 2, but significant only in interaction with designs in Period 2. In Period 3, both design and patent were significant. In low design-intensive sectors, designs are significant only in Period 3 in interaction terms with patents, whereas patents are significant only in Period 3 in 2000-2009.

From this result, several policy implications can be derived. The study shows how innovation policy should change its focus among the different IPR forms at different development stages. Putting together the results from the existing research, the following can be concluded. At the early stage of development or before 1987 in the ROK, firms' sales growth

is associated with petite patents (utility models) (Kim et al. 2012). During the catch-up stages or since 1987 in the ROK, two pathways can be expected: the trademark-oriented sector, which tends to be mostly domestic market-oriented (Kang et al.2019), and the design-oriented sector, which tends to be mostly export-oriented. At the stage of globalization and maturing or since 2000-2009 in the ROK, regular patents become more important in all sectors. Thus, to develop Asia, not only regular patents but also designs or trademarks can be the effective forms of IPR at different stages or sectors. To compete in the world market (exports), design is likewise significant besides patents.

REFERENCES

Ahire, S.L. and P. Dreyfus. 2000. The impact of design management and process management on quality: an empirical examination. *Journal of Operations Management* 18, pp. 549–575.

Awokuse, T. O. and H Yin. 2010. Intellectual property rights protection and the surge in FDI in China. *Journal of Comparative Economics*, 38(2), pp. 217–224.

Bently, Leonel and Brad Sherman. 2001. *Intellectual Property Law*. England: Oxford University Press.

Block, J. H., C. O. Fisch, A. Hahn, and P. H. Sandner. 2015. Why do SMEs file trademarks? Insights from firms in innovative industries. *Research Policy*, 44(10), pp. 1915–1930.

Bidiricia, Melike and Eda Bohur. 2015. Design and Economic Growth: Panel Cointegration and Causality Analysis, *Procedia - Social and Behavioral Sciences* 210, pp. 193–202.

Chiva, R. and J. Alegre. 2009. Organizational learning capability and job satisfaction: An empirical assessment in the ceramic tile industry. *British Journal of Management*, 20(3), pp. 323–340.

Cho, Dong-Sung. 2004. Design, Economic Development, and National Policy: Lessons from Korea, *Design Management Review*, Fall 2004. pp. 10–20.

Chung, Kyung-Won. 2003. *Design, brand, and competitiveness*. Woongjin Books: Republic of Korea.

Colombo, M. G., M. Delmastro, and L. Rabbiosi. 2012. Organizational design and firm performance. In *The Oxford Handbook of Managerial Economics*.

Hobday, M. 1995. East Asian latecomer firms: learning the technology of electronics. *World development*, *23*(7), pp. 1171–1193.

Jung, M. and K. Lee. 2010. Sectoral systems of innovation and productivity catch-up: determinants of the productivity gap between Korean and Japanese firms. *Industrial and Corporate Change,* 19(4), pp. 1037–1069.

Kang, Raeyoon, Taehyun Jung, and Keun Lee. 2019. Intellectual property rights and Korean economic development: the roles of patents, utility models and trademarks, *Area Development and Policy*, DOI: 10.1080/23792949.2019.1585889

Kim, L. 1997. *Imitation to innovation: The dynamics of Korea's technological learning.* Boston: Harvard Business Press.

Kim, Y. K., K. Lee, W.G. Park, and K. Choo. 2012. Appropriate intellectual property protection and economic growth in countries at different levels of development. *Research policy*, *41*(2), pp. 358–375.

Kline, S. J. and N. Rosenberg. 1986. *An Overview of Innovation-The Positive Sum Strategy:*

Harnessing Technology for Economic Growth. {City}.

Lee, Il Kyoo and Kyung Lee. 2008. Effects of the Korean Government`s Design Development Assistance Program on Corporate Achievements, *Journal of the Korean Society Design Culture* 14(4), pp. 409–417.

Lee, K. 2013. How can Korea be a role model for catch-up development? A 'capability-based'view. *Achieving Development Success: Strategies and Lessons from the Developing World*, 25.

Lee, Keun, Jaeyong Song, and Jooyoung Kwak. 2015. An Exploratory Study on the Transition from OEM to OBM: Case Studies of SMEs in Korea. *Industry and Innovation*. 22. 10.1080/13662716.2015.1064257.

Lee, Keun. 2019. *The Art of Economic Catch-up: Barriers, detours and leapfrogging in innovation systems*. {City}: Cambridge Univ. Press.

Lee, Keun, D. Park, and C. Lim. 2003. Industrial Property Rights and Technological Development in the Republic of Korea. *WIPO policy monograph*, April, Geneva.

Maskus, K. E. and M. Penubarti. 1995. How trade-related are intellectual property rights? *Journal of International economics*, 39(3-4), pp. 227–248.

Mendonça, S., T. S. Pereira, and M. M. Godinho. 2004. Trademarks as an indicator of innovation and industrial change. *Research Policy*, *33*(9), pp. 1385-1404.

Organisation for Economic Co-operation and Development. 1992. *Technology and Economy: The key Relationship.* Paris.

Rothwell, R. and P. Gardiner. 1983. The role of design in product and process change. *Design Studies*, *4*(3), pp. 161–169.

Rothwell, R. 1992. Developments towards the fifth generation model of innovation. *Technology Analysis & Strategic Management*, *4*(1), pp. 73–75.

Sandner, P. G. and J. Block. 2011. The market value of R&D, patents, and trademarks. *Research Policy*, *40*(7), pp. 969–985.

Smith, P. J. 1999. Are weak patent rights a barrier to US exports? *Journal of international Economics,* 48(1), pp. 151–177.

Verganti, R. 2009. *Design driven innovation*. Boston: Harvard Business School Press.

Walsh, V. 1996. Design, innovation and the boundaries of the firm. *Research policy*, *25*(4), pp. 509–529.