Not Patents but Trademarks-based Path of Technological Development of Latecomers: Evidence from the Korean Data

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Abstract

In contrast to the vast literature on verifying the importance of formal R&D activities measured as patent registrations, this paper explores the possibility of not patent but trademark-driven path of latecomer firms' technological development. The study is motivated by the evidence from the Korean data showing the existence of two groups of sectors where firms in the one group tended to file more trademarks than patents throughout the long period of time or more than four decades. We find that in the first group of sectors, like food, apparel, and pharmaceuticals, trademarks have been the dominant form of the IPRs with a much large number of their registrations than patents from the initial stage of development until recently, whereas in the second groups of sectors, like electronics and automobiles the main IPR form has been patents during the 1990s, the 2000s, and until today. Regressions on the determinants about this bifurcation find that the trademark dominant groups are those sectors involving more tacit knowledge and/or domestic market orientation associated with slow progress in technological capabilities. The results are important because it implies the existence of alternative path of economic development by the latecomer firms in different sectors, beside the patent-driven path which is already verified in Kim et al. (2012).

Keywords: trademarks; patents; Korea; tacit knowledge, sectoral systems of innovations

1. Introduction

The role of intellectual property rights (IPRs) in the economic growth of countries has long been the topic of academic research and policy debates. While some evidence of the effects of strong IPRs, particularly patent rights, on economic growth exists, the debate is far from settled and the evidence is mixed.[1] Thus, the literature has shifted to the possibility that IPRs could have differential effects on countries at different stages of economic development, and its importance has first been acknowledged in a World Bank publication (Fink and Maskus 2005). Actually, there have existed a large volume of the literature, albeit with mixed results, that tended to focus on this dynamic relationship between the protection of intellectual property rights and economic growth at different stages, such as Kanwar and Evenson (2003), Falvey, Foster and Greenaway (2004). Then, Kim et al (2012) turned to the new issue of the impacts of the different *types* of IPRs, rather than the *strength* of IPRs, that would be appropriate for countries at different stages of economic development. Given that through adaptation, imitation, and incremental innovation, firms in developing economies can acquire knowledge and enjoy some learning-by-doing (Suthersanen 2006), and the innovations they produce may not have the inventive step to merit a traditional patent, Kim et al (2012) suggested and verified the idea that the second-tier industrial property right, namely, a utility model (petit patents) may be relevant and useful at lower level of development, serving as stepping stone for further technological progress.

Thus, Kim et al (2012) find, by country-panel analysis, that the efficacy of regular patents and utility models on innovation and growth do vary by level of development; in the

[1] See Aghion et al. (2001), Boldrin and Levine (2006), and Eicher and Penalosa (2008) for a review of the theoretical debates.

developed world, patent protection contributes to innovation and economic growth, while utility models play a negligible role; in contrast, in the developing world, utility models strongly and positively contribute to innovation and growth, while patenting has weak or negative influences. They also find parallel evidence at the firm-level, using the Korean firms, that utility models are important to innovation and firm growth when firms are technologically lagging, and once firms become more technologically advanced, their performance is driven less by utility model innovations but more by inventive patentable innovations. Given the linkage of the petit patents at the early state and the regular patents at late stage, what they have found is the patent-driven path of technological development of the latecomer firms.

This study starts by asking whether there is an alternative path of technological development. In seeking an answer to this question of possibility of non-patent driven path, this paper pay attention to the role of trademarks. Registering the trademarks is a brand strategy, as the name can contain the value of the product (Economides 1987). A trademark encourages firms to make good products and to adhere to a consistent level of quality. Thus, a product made with the use of tacit knowledge can be protected and distinguished from competitors in the market and can establish market power through the registrations of a trademark. Recently, trademarks have been recognized as another proxy measure of innovation, complementing or substituting patents (Allegrezza and Guard Rauchs 1999; Schmoch 2003; Mendonça et al. 2004; Bosworth and Rogers 2001; Malmberg 2005; Greenhalgh and Rogers 2007; Sandner and Block 2011; Mehrazeen et al. 2012). While both patents and utility models deal with technological or scientific invention or improvement, trademarks are more a market-based IPR than a technology-based IPR.

We see a possible existence of trademark-based path of technological development from the Korean data. We find that in some sectors like food, apparel, and pharmaceuticals, trademarks have been the dominant form of the IPRs with a much large number of their registrations than patents from the initial stage of development until recently, in contrast to other sectors, like electronics and automobiles, where the main IPR form has been patents during the 1990s and the 2000s. Then, we should find out the reasons for the differences across these sectors in terms of the relative number of the registered trademarks and patents.

In this effort, we rely on the concept of the sectoral system of innovation (SSI) which looks at the technological, market and institutional regimes of the sectors, such as Malerba (2002, 2004) in the developed world context or Malerba and Mani (2009) in the developing world context. While it is argued that trademarks may also represent innovations, they can be filed even without formal R&D activities targeting technological advances. Thus, one may hypothesize that those sectors relying on trademarks than patents may be those lagging in terms of technological advances and thus more oriented toward domestic markets than international markets. We also note that patents tend to reflect more codifiable or explicit knowledge than tacit knowledge. Then, one may hypothesize that those trademark-dominant sectors correspond to the sectors with their knowledge more tacit than codifiable.

To verify these reasoning and hypotheses, we look in section two at the sectoral trend of the registered number of patents and trademarks from 1971 to 2010 in Korea, and then we review the theoretical literature in section 3 to derive hypothesis. Section four conducts regression analysis to verify the hypothesis. Section five concludes the paper.

2. Using the Firm-Level Data to Identify the Trademark- and Patent-dominant Sectors

In Korea, patent law (US military government command No. 91) began its registration since 1946 and trademark law was established in 1949. At the initial stage of economic development in Korea, registration of IPRs were not frequent and most rights were applied by individuals or foreign companies. Application and registration of IPR by domestic firms began later than individual or foreign companies. Especially, firms registered only trademark until 1955, and IPR applications by firms were all accepted without rejection till the mid-1970s. Patent and utility model were rarely registered comparing to trademark, and total amounts of IPR registrations were smaller than that of latter periods.

From the mid-1970s, when the economy shifted from light industry to heavy and chemical industries, large firms began to invest in learning foreign technology to build their capabilities. And from early 1980s, firms have established private research center to expand their technological abilities by in-house R&D. At the same time, both firms and government increased R&D expenditure that the ratio of R&D/GDP reached 1% by the mid-1980s and surpassed 2% by the mid-1990s. As a result, registration of utility model and patent increased after the mid-1980s. Until early 1990s, utility models play the role of stepping-stone for technological development as Kim et al (2012) analyzed, in this period registration of utility model surpassed that of patent.

To analyze sectoral differences in the dominant forms of IPR across sectors, we have constructed the firm -level data covering 1971-2010. Patent and trademark data are downloaded from the KIPRIS (Korea Intellectual Property Rights Information System). To build the financial data on Korean external auditing or listed companies, we use the database of the Center for Economic Catch-Up (CEC) until 1979 and the Korea Information Service (KIS) from 1980 through 2010. Because both the IPR data and the financial data are downloadable as firm value, we modify the sector-level variable to the total sum of individual firm-level data in each sector. To include data of extinct firms, we use the 8th Korean Standard Industrial Classification. After matching IPR data and financial data by corporation code, we build sector-level panel data with 138 sectors classified by the KSIC 4-digit industry code.

From the firm-level IPR registration data in Korea over the 1970s to 2010, we find that trademarks are dominant throughout the whole period in some sectors (see Figure 1A)., whereas in other sectors the dominant form of the IPR changes to the patent from the 1990s (see Figure 1B). The first group, the trademark-dominant group, includes typical light industry (e.g., food, apparel), some chemicals and pharmaceuticals. Firms in these sectors registered trademarks more than any other IPRs throughout the whole period The second group, the patent group, include most of the heavy industries (e.g., synthetic chemicals, iron/steel industry, and electronics), and automobiles

[Figure, 1 here]

Now in table 1 and table 2, the trademark group and patent group are presented, respectively, in terms of the ratio of the number of patents to the number of trademarks. This ratio is calculated using the total number of registered patents in each sector of each year divided by the total number of registered trademarks in each sector of each year. According to these tables, it is apparent that the two groups differ in their uses of IPR forms.

The case of the patent-dominant group is consistent with the finding of Kim et al. (2012) which analyzed and compared the firm-level patent and utility model data divided into the different periods. Specifically, at the early stage or before 1987, utility model were the dominant forms of IPR which is correlated with firm's financial performance, whereas in the later stage or after 1987, the firms mainly switched to file patents reflecting the enhanced level of their technological capabilities which also translated into performance. However, they did not consider the impact of the sectoral heterogeneity in this relationship among IPR forms, sectors' knowledge base, and performance, and failed to consider the possibility of non-patent-driven path of latecomer firm development and catch-up. This study considers both patents and trademarks, and classify the sectors by the registration patterns of patents and trademarks and investigate the differences between the groups. We conject that this difference might arise from different knowledge bases and the degree of technological strength across the sector at different time periods.

[Table 1 and 2, here]

3. Sectoral Heterogeneity and Hypotheses

1) Different knowledge bases of sectors

Technological knowledge involves varying degrees of specificity, tacitness, complementarities and independence and may greatly differ across sectors and technologies (Nelson and Winter 1982). The main advantages of a sectoral system view can be identified in a better understanding of the structure and boundaries of a sector – that is, the agents and their interactions; the learning, innovation and production processes; the transformation of sectors; and the factors at the basis of the differential performance of firms and countries in a sector (Malerba 2002). When we focus on sectoral differences, we can find several classifications of sectors with diverse criteria. First, the Schumpeter Mark I and Schumpeter Mark II models are classified by innovative activities at the sectoral level. Schumpeter Mark I is characterized by "creative destruction", with technological ease of entry and a major role played by entrepreneurs and new firms in innovative activities. New firms' entry is challengeable for incumbents and continuously disrupts the present methods of production, organization and distribution. Schumpeter Mark II is characterized by "creative accumulation" with the prevalence of large established firms and the presence of relevant barriers to entry for new innovators according to the ability of industrial R&D labs (Malerba 2002). Another classification of sectors is by Pavitt (1984), who put forward a taxonomy based on differences in the process of innovation, rather than a product-based industrial classification. As noted in Table 3, Pavitt explains the sectoral patterns of technical changes using the data of 2000 innovations in Britain from 1945 to 1979; these classifications are: (1) supplier-dominated industries, (2) scale-intensive industries, (3) specialized equipment suppliers and (4) science-based industries.

[Tables 3 , and 4, here]

Also Asheim (2007) categorized sectors by knowledge base (see Table 4). He emphasized that the innovation process of firms differs substantially among various industries and sectors whose activities require specific knowledge bases (Asheim & Gertler, 2005; Asheim & Coenen, 2006). He distinguished sectors according to three types of knowledge base: 'analytical' (science-based), 'synthetic' (engineering-based) [2] and 'symbolic' (creativity-based). These types indicate different mixes of tacit and codified knowledge, codification possibilities and limits, qualifications and skills, required organizations and institutions involved, and specific innovation challenges and pressures from the globalizing economy (Asheim 2007). Pavitt's taxonomy can be connected with Asheim's as follows: supplier-dominated and scale-incentive industries are related to synthetic knowledge, whereas science-based and specialized suppliers are related to analytical knowledge.

From these classifications, we can infer that the main difference of the sectoral separation stems from whether or not the technology of the knowledge is scientific. In terms of technological regime, appropriability appears differently in each category. In scientific or analytical types, codified knowledge or patents are used, whereas in non-scientific or synthetic types, tacit knowledge is used. The codifiability of knowledge is a similar concept to explicitness, and it represents the extent to which a given knowledge item can be reduced to information by means of drawings, formulae, numbers or words. On the other hand, tacit knowledge can only be observed through its application and can only be acquired through practice (Grant 1996; Spender, 1996; González and Mariano, 2007).

When technological knowledge is invented or acquired, firms usually use various instruments to protect the results of their innovative activities from imitation (Dosi et al. 2006). Such instruments can be distinguished into legal property rights like patents or trademarks and unofficial forms like know-how (Castellacci and Zheng 2010). The percentage of patented innovations varies by sector according to the appropriability of the technology innovation, as mentioned in previous researches (Levin et al. 1987; Harabi 1995; Arundel and Kabla 1998). Also, firms that regard know-how or secrecy to be an important protection method for innovative products are less likely to apply patents (Arundel and Kabla 1998), and these are types of tacit knowledge. Tacitness refers to the situation in which some technological information about production is embodied in the product or other protector. This kind of knowledge is usually acquired by means of training and interaction with other people or the environment. Tacit knowledge is implicit and idiosyncratic; at the organisational level, it is embedded in routines and capabilities (Teece and Pisano 1994). Generally, tacit knowledge is

[2] Laestadius (1998).

not expressed in words but instead is embedded in products, such that the name of the product might reflect the quality of the goods. Moreover, tacit knowledge is usually correlated with non-scientific type sectors. Thus, we suppose that in tacit-knowledge-dominant sectors, firms may be likely to apply for IPRs other than patents.

If the technological knowledge of a sector can be easily formulated, firms in the sector can apply for a patent to protect their new invention. However, if the knowledge is hard to codify, firms must find another protection method. In other words, different degrees of knowledge explicitness affect the extent of patent registration. Explicit knowledge is usually described as patentable because the information can be explained in words, while tacit knowledge is rarely protected by patents because a patent application with this knowledge would be vague or misleading (Arora 1997). Thus, the patent system is effective in protecting explicit knowledge (Pitkethly 2001).

If the product is made using more tacit than codifiable knowledge, it is difficult for competitors to imitate, because tacit knowledge is exposed only through its productive activity (Grant 1996). However, a lack of clear legal protection may result in uncertainty regarding the ownership of knowledge in the market. Therefore, many firms try to find an appropriate method to protect their products made using tacit knowledge. In addition to protection, acknowledgment of the quality or function of the product to the customers is also important to the market strategy. Thus, tacit knowledge is usually represented via symbols, diagrams, or various techniques of expression (Stewart 1997; Nonaka 2008). Among such representations, we may consider a trademark as a defense mechanism to protect tacit knowledge.

2) Hypotheses

As discussed in section 2, when we examine the dynamic patterns of the two groups, patent- and trademark-dominant groups, over the periods, there are two stylized facts needing explanations. First, at the beginning of Korea's industrial development, trademarks were the main IPR in almost all sectors as typical manufacturing firms registered trademarks more than other IPRs until 1980s. This is consistent with the fact that until the late 1980s in-house R&D of firms were very low or be just starting and thus had no technological innovations to file patents (Chung and Lee 2015). Second, the division of the two groups appeared only after the mid-1990 (i.e., after a certain level of technological development was achieved). Even after the mid 1990s, the firms in the trademark group continue to register trademarks more than patents. However, this does not necessarily mean that the firms in this group did not do any R&D but may reflect the fact that the R&D outcomes might not be patentable as they involve more tacit knowledge, reflecting the knowledge base of the sectors. We can therefore suppose that the registrations of trademarks and patents are related to the both different sectoral knowledge bases and the different levels of technological capabilities of the firms in the different sectors.

The trademark group appears similar to Pavitt's scale-intensive and supplier-dominated industry and Asheim's synthetic sector, involving more tacit knowledge than codifiable knowledge. However, it is not exactly the same as these categories, because in our classification pharmaceuticals is in this trademark group. The case of pharmaceuticals cab be explained in terms of its slow or lagging development of technological capabilities and its domestic market orientation, quite different from IT with strong and rapid technological advance and export orientation. Given that Korean pharmaceutical industry has grown through producing license-in or generics products until recently, the main IPR of this industry is trademark. In general, when firms had no capability to produce complex or scientific products, a trademark would be the only means to protect these companies' products in the market. Filing more trademark also imply that they are more oriented toward domestic markets.

The firms in the second group, patent-group, used be also filing more trademarks than patent until 1980s but they soon changed their main IPR from trademarks to patents after the mid-1990s with the progress of their R&D activities. This group is similar to Pavitt's science-based and specialized supplier industry and Asheim's analytical sector, involving more codifiable knowledge. However, the automobile sector in this patent group cannot be explained in this Pavitt's or Asheim's classification. The reason that autos are in this group has to with the fact that it has achieved rapid technological development of automobiles after 1990s led by the Hyundai Motors.[3] In this group, the number of the registered utility models exceeded that of trademarks from the early 1980s, and then the patent soon became the most frequently registered IPR over the utility models since the mid-1990s to today.

In contrast, firms in the trademark-dominant group have continued to today to register trademarks more than patents. Is it thus correct to conclude that technological development occurred only in the patent group? We do not think this is the case. Rather, it is reasonable to suppose that technological development would have occurred in every manufacturing sector, but there would be some differences in their knowledge base. In other words, in this trademark group firms' technological capability seems to have reflected in the increasing registration of trademarks because of the different knowledge bases in this sector.

In light of the above discussion, the main hypotheses can be stated as follows.

[3] Hyundai motors developed the α-engine independently in 1991 and established a private research center in 1996 (http://pr.hyundai.com/#/Pages/Intro/Report/ReportList.aspx). Kia motors was acquired by Hyundai motors in 2000.

The differences in the number of the registered trademarks and patents across are affected by sectoral differences in knowledge base and level of technological capabilities (market orientation) of the firms in sectors.

Specifically, the above means that the trademark dominant groups tend to be featured by their knowledge base involving more tacit knowledge and also low level of technological development (and thus more domestic market oriented).

In verify this hypothesis, we rely on the definition of tacitness or inverse of explicitness used in Jung and Lee (2010).[4] They calculate explicitness using patent registration counts and the amount of R&D investment of a sector as follows.

Explicitness of knowledge of a sector = the number of patents registered divided by R&D expenditure of a sector.

This measure of knowledge explicitness is built on the idea that a sector with more codifiable knowledge would end up filing more patents per unit of R&D expenditure than other sectors with more tacit knowledge. This measure explicitness is consistent with Gonzalez and Mariano's (2007) observation that firms that mainly use explicit knowledge choose the patenting system as a protection method, while those that rely more on tacit knowledge are inclined to remain private rather than use patents.

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[4] Including explicitness, they set up a model with other variables to identify the determinants of total factor productivity (TFP) catch-up by Korean firms compared to that of Japanese firms from the view of the sectoral systems of innovation. They find that TFP catch-up was faster in sectors with explicit knowledge.

4. Data, Regression Models and the Result

Table 5 explains the key variables used in the regression, and Table 6 presents their descriptive statistics, divided into the trademark group and the patent group for the whole period, from 1971 to 2010. Table 6 clearly show the heterogeneity of the two groups as it is shown that the level of knowledge explicitness, top 5 firm share, and R&D intensity are all higher in the patent group than in the trademark group. Only the advertising-intensity ratio of the trademark group is higher than that of the patent group. T-test results of these differences are also described in the table. Here, both a sector's share in total export and export-to-sales ratio of a sector is the proxy for the technological capabilities of the sector. Table 7 presents the correlations.

[Table 5, 6 , 7 here]

We now run regressions to find out the determinants of the two different paths of technological development of latecomer firms. For this, the sectors are classified into two groups, with a dummy for the trademark group with a value of one.

First, we estimate a probit model appropriate for a qualitative binary dependent variable. In the first analysis, the value of the group dummy is fixed as 1 if the sector is in the trademark group and 0 if the sector is in the patent group, regardless of the year. Thus, we estimate the result as a pooled probit regression model as follows.

(1) $Group\ dummy\ pre\text{-}fixed = \beta_0 +$

$\beta_1 Explicit_{t-1} + \beta_2 (Export\_share_{t-1}) + \beta_3 (Ad\_inten\_ratio_{t-1.})$

$+\beta_4 (Top\ 5\ sales\_ratio_{t-1.}) + \beta_5 (R\&D\_inten\_ratio_{t-1.}) + \varepsilon$

The results of the pooled probit regression are presented in table 8. The dependent variable is the group dummy, which is pre-fixed according to the pre-classified group types. Because the group dummy represents trademark group, we expect that explicitness is negatively related to the trademark group, (explicitness is an inverse of tacitness). The probit regression result show that explicitness has a negative and significant relation with the dummy of the trademark group, as we expected.

Another point to confirm is the relation between the trademark group dummy and export performance measured by a sector's share in total exports or export-to-sale ratio of each sector.. The results show that the export share has negative and significant relation with trademark group dummy. When we try with another measure of export-orientation (ratio of exports to sector' sale), we obtain the consistent results (not reported here). Among other explanatory variables, advertising intensity is positively related to trademark group, whereas R&D intensity and the top5 sales share are negatively related to the dummy of the trademark group. To check robustness, we also run regressions without explicitness in models 3 and 4. The results are almost the same regardless of this. .

[Table 8, 9, 10, here]

In the regressions, the period dummies are also included. The period covered is divided into three sub-periods – 1971-1986, 1987-1997, and 1998-2010 – in view of the important events in Korean economic history. Since the mid-1980s, Korea has emphasized in-house R&D in the private sector, and considerable public-private joint R&D has been set up to conduct R&D projects (Lee 2013). Also, in 1987, the patent law was revised extensively, including substance patents. Following Kim et al. (2012), we identify 1986 as the first division of the three periods. The second division is the year of the Asian financial crisis of 1987. The effect of the crisis was huge, so it is an inevitable selection for dividing the latter period. In table 6, other variables are described.

Second, for robustness, we try another way of grouping where the dummy for the trademark takes the value of 1 for the years when the number of trademarks is greater than that of patents. Thus, the value of the group dummy now may change even in the same sector over the years according to the variation of the ratio of patent to trademark in each year. With this group dummy, we run a panel random probit model regression to check sector-specific effects according to periods. Table 9 shows the result of panel random probit regression with this varying dummy. The results are consistent with those with a pre-fixed group dummy reported in the preceding table of 8.

Third or in the final analysis, we run firm-level regressions on the relative ratio of the number of the registered trademarks and patents, with both firm-level and sector-level variables. Now, the model is as follows:

$$(2)\ Trademarks/Patents_{i,t}=\beta_0 + \beta_1 Explicit_{I,t-1}+\beta_2(Export\ share_{I,t-1})+\beta_3(Top\ 5\ sale\ share_{I,t-1.}) + \beta_4 Employees_{i,t-1} + \beta_5(Adverterising - Intensity)_{i,t-1.} + \beta_6(R\&D\_inten\_ratio)_{i,t-1.} + \beta_7 Firm\ age + \varepsilon$$

In this model, explicitness, export share and top 5 firms' sales share are sector-level variables, whereas the number of employees (representing firm size), advertising intensity, R&D intensity and firm age are firm-level variables. Table 10 shows the results. In both the OLS and the fixed effect regression result, knowledge explicitness is significant and negatively related to the trademarks to patent ratio, which implies that firms in sectors with higher degree of knowledge explicitness tend to file more patents than trademarks. The coefficients of both export shares and export to sectoral sales ratio are negative and significant, which is consistent with those of probit regression.

5. Concluding Remarks

In contrast to the vast literature on verifying the importance of formal R&D activities measured as patent registrations, this paper explores the possibility of not patent but trademark-driven path of latecomer firms' technological development. The study is motivated by the evidence from the Korean data showing the existence of two groups of sectors where firms in the one group tended to file more trademarks than patents throughout the long period of time or more than four decades. We find that in the first group of sectors, like food, apparel, and pharmaceuticals, trademarks have been the dominant form of the IPRs with a much large number of their registrations than patents from the initial stage of development until recently, whereas in the second groups of sectors, like electronics and automobiles the main IPR form has been patents during the 1990s, the 2000s, and until today.

Such bifurcation of the sectors into the trademark vs. patent-dominant groups is explained by regressions on its determinants, and we find that it has to do with both different sectoral knowledge bases (esp, tacitness of knowledge) and the different levels of technological capabilities of the firms in the different sectors and the different market-orientation. We confirm that the trademark dominant groups are those sectors involving more tacit knowledge and domestic market orientation associated with slow progress in technological capabilities. These results imply that firms facing slow technological progress in mostly tacit knowledge-based sectors have tended to rely on trademarks in their growth based on domestic market than export markets. The results are important because it implies the existence of alternative path of economic development by the latecomer firms in different sectors, beside the patent-driven path which is already verified in Kim et al.(2012).

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[Table 1] Trademark group: Ratio of patents to trademarks (patent/trademark)

Trademark group	1970s	1980s	1990s	2000s	Number of firms
Food and Beverage	0.010	0.025	0.070	0.054	363
Textile & Fabric Weaving	0.003	0.062	0.203	0.277	251
Apparel	0.000	0.012	0.005	0.012	239
Leather & Shoes	0.000	0.000	0.013	0.043	87
Wood & Furniture	0.000	0.022	0.004	0.233	31
Paper	0.200	0.078	0.199	0.158	112
Printing	0.000	0.000	0.008	0.032	169
Oil Refining	0.000	0.346	0.361	0.298	25
Basic Chemicals	0.024	0.121	0.281	0.440	348
Pharmaceuticals	0.022	0.034	0.091	0.124	174
Rubbers (except tires) & Plastics	0.066	0.060	0.362	0.865	330
Cement & Non-Metals	0.022	0.449	0.847	0.549	187
Other Manufacturing (toy, sport goods, ornaments)	0.000	0.022	0.073	0.172	227

[Table 2] Patent group: Ratio of patents to trademarks (patent/trademark)

Patent group	1970s	1980s	1990s	2000s	Number of firms
Synthetic Chemicals	0.024	0.187	0.665	2.636	108
Rubber Tires	0.000	0.025	2.079	2.947	6
Iron & Steel Manufacturing	0.131	1.365	7.810	9.969	226
Fabricated Metal	0.021	0.044	0.508	1.312	385
Machinery	0.028	0.133	1.516	3.347	979
Computers	0.000	0.018	0.518	1.539	156
Electrical Machinery	0.107	0.826	2.843	3.050	414
Electronics	0.078	1.125	14.842	16.632	1004
Optical & Medical Instruments	0.000	0.356	2.226	2.564	255
Automobile	0.030	0.139	10.575	13.057	454
Ship Building & Vehicles	0.000	0.707	4.143	3.772	79

[Table 3] Innovation patterns in the Pavitt's taxonomy

Sector type/ variables	Supplier dominated	Scale Intensive	Specialized suppliers	Science Based
Firm size	Small firms	Large firms	Small firms	Large firms
Type of innovation	Processes	Processes	Products	Mixed products and processes
Locus of innovation	External	Production	Decentralized	R&D departments
Sources of innovation	Specialized suppliers	Production and specialized suppliers	Science based firms/customers	Universities and research centers
Means of appropriability	Tacit knowledge	Tacit knowledge and entry barriers	Tacit knowledge/reputation	Patents and entry barriers
Competitive parameter	Quality/performance	Price/ quality Price	Quality/performance	Performance/quality/ price
Sectors	Stone/glass	Automobiles	Mechanical engineering	Pharmaceuticals/ microelectronics
Trajectories	Improvements in process yields	Improvements in process yields and increases in the scale of production processes and automation	Improvements in performance and reliability of products	Performance and physical properties and improvements in process yields
Learning regime	Learning by using	Learning by doing/ learning by using	Learning by interacting/learning by doing	Learning by searching/learning by doing

*Source: Kristensen (1999: p4)

[Table 4] The three knowledge bases by Asheim

Analytical	Synthetic	Symbolic
Innovation by creation of new knowledge	Innovation by application or novel combination of existing knowledge	Innovation by recombination of existing knowledge in new ways
Importance of scientific knowledge often based on deductive processes and formal models	Importance of applied, problem-related knowledge (engineering), often through inductive processes	Importance of re-using or challenging existing conventions
Research collaboration between firms (R&D department) and research organizations	Interactive learning with clients and suppliers	Learning through interaction in the professional community, learning from youth/street culture or 'fine' culture and interaction with 'border' professional communities

Dominance of codified knowledge due to documentation in patents and publications	Dominance of tacit knowledge due to more concrete know-how, craft and practical skill	Reliance on tacit knowledge, craft and practical skills and search skills
Biotechnology/Pharmaceuticals /Electronics [5]	Automotive/Food	Advertisement

*Source: Asheim (2007: p227), Asheim and Coenen (2005: p1183)

5 Asheim and Coenen (2005) classified electronics have both analytical and Synthetic knowledge base.

[Table 5] Description of the Key Variables

Variable	Description
Group dummy	1 if the sector is in Trademark dominant group
Group gummy2	1 if the restarted numbers of trademark are larger than that of patent in each sector
Explicitness	number of patents registered in each sector /R&D expenditure in each sector
Export_share [6]	total export of each sector /total export of whole sector
Export_sales ratio	total export of in each sector / sales in each sector
Advertising_Intensity	total advertising cost of firms in each sector /total sales in each sector
Top5 firm_share	top 5 firms' sales in each sector/total sales in each sector
R&D_Intensity	total R&D of firms in each sector/total sales of firms in each sector

[Table 6] Descriptive statistics: Trademark group vs. Patent group (entire period, sector level)

	Total		Patent group		Trademark group		T-test	
Variable	Mean	SD	Mean	SD	Mean	SD	t	p-value
Number of Patent	171.012	1438.088	400.563	2258.972	19.469	88.937	8.872	0.000***
Number of Utility model	62.897	650.288	147.399	1025.33	7.111	20.107	7.202	0.000***
Number of Trademark	66.199	193.084	31.687	87.908	88.983	235.576	-9.957	0.000***
Explicitness	0.00015	0.007	0.00036	0.01036	0.00001	0.00006	1.568	0.11
Export_share	4.173	4.511	6.242	5.747	2.809	2.704	27.208	0.000***
Export_sales ratio	0.00043	0.00058	0.00064	0.00071	0.00029	0.00041	20.626	0.000***
Advertising_ Intensity	0.011	0.022	0.003	0.004	0.017	0.027	-20.699	0.000***
Top5_firm_ share	0.216	0.161	0.254	0.161	0.191	0.156	13.116	0.000***
R&D_ Intensity	0.007	0.085	0.012	0.131	0.004	0.024	2.928	0.003***
Number of sector	138		84		54			

[6] We build this variable with UN comtrade database(http://comtrade.un.org/data/) and Korea Trade Statistics Promotion Institute database (http://www.trass.or.kr/service/statistic/StatisticsViewServlet?mainServiceURL=P02M02D021).

[Table 7] Correlation Table

	Group dummy	Explicitness	Export_ share	Top 5 sales_share	Advertising- Intensity	R&D_ Intensity
Group dummy	1					
Explicitness	-0.0347	1				
Export_share ratio	-0.2541	0.0304	1			
Top 5 sales_share	-0.123	-0.0099	0.2373	1		
Advertising_Intensity	0.2456	-0.0122	-0.2027	-0.2484	1	
R&D_Intensity	-0.2173	0.0084	0.1348	0.1347	-0.0319	1

[Table 8] Pooled probit regression of Pre-fixed Trademark Group Dummy

VARIABLES	Model (1) Pooled probit	Model (2) Pooled probit	Model (3) Pooled probit	Model (4) Pooled probit
Explicitness(t-1)	-0.603*	-0.637**		
	(-1.826)	(-1.998)		
Export_share(t-1)	-0.112***	-0.132***	-0.112***	-0.132***
	(-18.259)	(-22.525)	(-18.240)	(-22.510)
Top 5 firm sales share(t-1)	-0.781***		-0.776***	
	(-4.917)		(-4.888)	
Advertising intensity (t-1)	65.240***		65.342***	
	(17.098)		(17.135)	
R&D_Intensity (t-1)	-3.456***		-3.416***	
	(-4.228)		(-4.179)	
Period_2	-0.294***	-0.016	-0.294***	-0.017
	(-4.690)	(-0.310)	(-4.700)	(-0.326)
Period_3	-0.141**	0.013	-0.144**	0.009
	(-2.396)	(0.269)	(-2.458)	(0.192)
Constant	0.635***	0.802***	0.628***	0.797***
	(9.067)	(18.404)	(8.981)	(18.330)
Observations	4,199	4,399	4,199	4,399

Note *** $p<0.01$, ** $p<0.05$, * $p<0.1$, z-statistics in parentheses
Period dummy: 1971-1996, 1987-1997, 1998-2010.

[Table 9] Panel random probit regression of a varying trademark Group Dummy

VARIABLES	Model (1) Random probit	Model (2) Random probit	Model (3) Random probit	Model (4) Random probit
Explicitness(t-1)	-0.308**	-0.301*		
	(-2.008)	(-1.957)		
Export_share (t-1)	-0.072***	-0.079***	-0.074***	-0.083***
	(-5.599)	(-6.086)	(-6.609)	(-7.747)
Top 5 sales share(t-1)	0.622		0.711*	
	-1.383		-1.799	
Advertising_intensity (t-1)	27.539***		25.818***	
	-4.902		-4.908	
R&D_Intensity (t-1)	-9.880***		-8.589***	
	(-4.519)		(-4.662)	
Period_2	-0.995***	-0.986***	-0.966***	-0.988***
	(-9.041)	(-9.827)	(-9.568)	(-11.515)
Period_3	-1.753***	-1.800***	-1.715***	-1.787***
	(-15.353)	(-17.822)	(-16.639)	(-21.225)
Constant	2.296***	2.672***	2.286***	2.690***
	(11.643)	(17.31)	(12.532)	(19.472)
lnsig2u	0.287	0.490***	0.216	0.365**
	(1.56)	(2.894)	(1.223)	(2.252)
Observations	3,600	3,633	4,118	4,398
Number of industry	138	138	138	138

Note *** p<0.01, ** p<0.05, * p<0.1, z-statistics in parentheses
Period dummy: 1971-1996, 1987-1997, 1998-2010.

[Table 10] Firm-Level Regression of the Trademarks to Patents Ratio

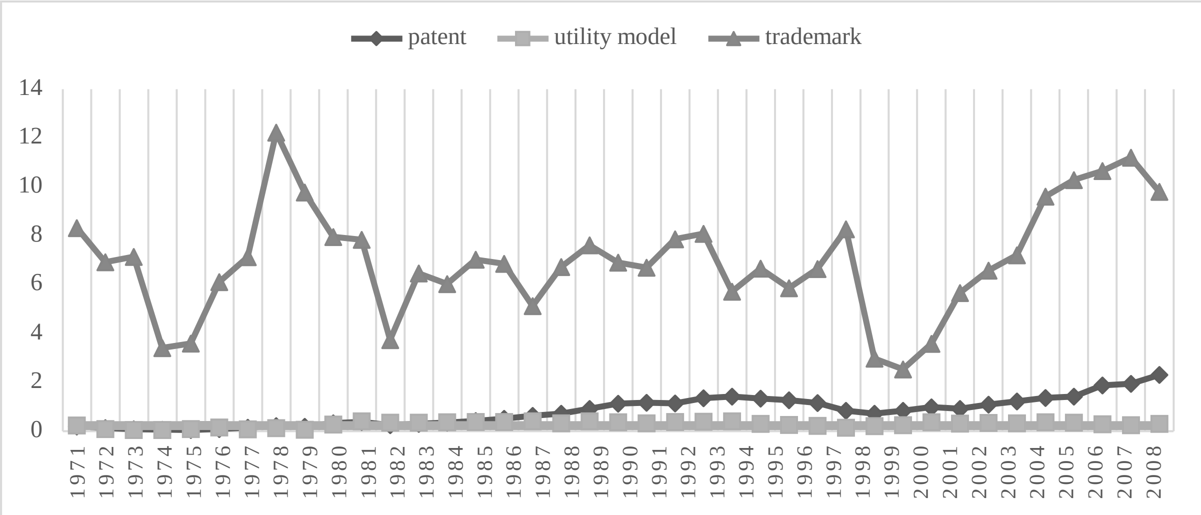
VARIABLES	Level	Model (1) OLS	Model (2) Fixed effect	Model (3) OLS	Model (4) Fixed effect
Explicitness(t-1)	Sector	-8.432***	-3.020*	-8.064***	-4.422**
		(-3.323)	(-1.743)	(-3.192)	(-2.526)
Export share(t-1)	Sector	-0.011***	-0.053***		
		(-17.224)	(-33.281)		
Export_ sales ratio (t-1)	Sector			-173.253***	-20.385***
				(-28.466)	(-2.906)
Top 5 sales share (t-1)	Sector	-0.585***	0.194***	-0.567***	-0.053
		(-17.170)	(2.907)	(-18.871)	(-0.782)
Employees(t-1)	Firm	-0.033***	-0.082***	-0.038***	-0.108***
		(-9.138)	(-13.440)	(-10.622)	(-17.529)
Advertising_intensity (t-1)	Firm	0.154***	0.039***	0.158***	0.045***
		(85.022)	(15.081)	(88.115)	(16.961)
R&D_Intensity(t-1)	Firm	-0.068***	-0.009***	-0.066***	-0.010***
		(-39.065)	(-5.628)	(-38.053)	(-6.135)
Firm age	Firm	0.146***	-0.013	0.146***	-0.010
		(27.496)	(-1.299)	(27.711)	(-0.974)
Constant		1.670***	1.320***	1.734***	1.268***
		(9.026)	(10.605)	(9.418)	(10.071)
Observations		56,675	56,675	56,675	56,675
R-squared		0.237	0.047	0.244	0.027
Hausman test			286.19		1005.43
Number of firms			5,795		5,795

t-statistics in parentheses

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

[Figure 1] Trend in the Number of Diverse IPR forms in Korea (firm-level average each year)

Panel A: The Case of the Trademark-dominant Group



Panel B: The Case of the Patent-dominant group