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Firms' Negative Perceptions on Patents, Technology Management Strategies, and Subsequent Performance

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Abstract: While patents do have many advantages, their disadvantages include requiring disclosure of technical information and imposing the burden of patenting and litigation costs. In this study, we investigate the relationship between a firm's negative perception on patents, technology management strategies, and subsequent performance. For this purpose, we use a categorical canonical correlation analysis of the top 200, large, R&D-intensive firms in Korea. We find that negative perceptions such as burdensome transaction costs, non-patenting culture, and uncertainty of the outcome of patent litigation are associated with firms' technology management strategies, such as purchase of licenses, and subsequent performance, such as an increase in the number of inventions from the cross-fertilization of different technologies. The results of this study are expected to contribute to a better understanding of firms' negative attitudes toward the effects of patents, their subsequent technology management strategies, and resulting performance.

Keywords: canonical correlation analysis; quantification method; R&D intensity; perception on patents; technology management strategy

1. Introduction

Patents have been considered an effective means of protecting technological innovations [1,2]. In addition, the patent system provides temporary exclusive rights to applicants, and it can thereby motivate them to create valuable innovations [3]. Recently, the interest in patents has increased steadily due to global patent lawsuits, the interrelationship between standards and patents, the patent thicket issue, and royalty pricing. In addition, patents are increasingly important for a firm's technology management [4]. Accordingly, many studies have examined the positive and negative effects of patents on a firm's technology management [1,3,5–10].

The positive aspects of patents include the ability to protect products and process technologies [5], create a retaliatory power against competitors [1,9], and block competitors from certain technological areas [10]. In addition, patents provide a competitive bargaining position in cross-licensing. Patents also help firms improve their image and attract venture capital financing [7,8,11]. The disclosure of technological information as a result of applying for a patent can also signal to customers, suppliers, banks, or future employees that the firm is a leader in the industry [12–14]. In addition, patents have a positive effect on the economic performance of firms [15].

However, the creation and maintenance of patents can place a financial burden on firms due to the costs associated with patenting and related transactions [3]. Litigation costs can leave small firms incapable of enforcing patent rights when a patent they hold is infringed upon [16]. In Korea, the amount of average statutory damages for patent infringement is approximately 50 million won, and this amount is significantly less than that in the United States (two billion won). This can instigate patent infringement because the infringer's profit arising from patent infringement can be much higher than the amount of the consequent statutory damages. In many cases, patent holders are not properly compensated for their loss from patent infringement. Moreover, firms are reluctant to disclose the technical information required when applying for a patent. Due to these negative aspects, firms do not try to protect their technologies with patents.

Both the positive and negative aspects of patents can be related to a firm's technology management and implementation strategies. In this study, we focus on the negative aspects of patents, which draw relatively less attention in the literature than the positive aspects. Of particular interest is the negative perception toward patents held by large R&D-intensive firms. What would be the main categories of the firms' negative perceptions? What types of technology management strategies would they employ given the existence of such negative perceptions? How would the implementation of such strategies affect the firms' performance? We apply the theory of planned behavior (TPB) to analyze firms' negative perceptions toward patents, technology management strategies, and subsequent performance.

Many studies consider the relationship between patent activity and firm performance [1,5,9,17–23] or the relationship between patent quality and a firm's innovative performance [24,25]. However, no study has yet examined the relationships among the perception on patents, firm strategies, and performance of technology management: A firm's technology management performance depends on its technology management strategies [26]; selection and implementation of these strategies can be affected by the firm's perception on patents. In particular, decision makers can create the necessary conditions to outperform their competitors through their own attitudes, including 'propensity to innovation, leadership attributes, visionary thinking, and long-term orientation' [27,28]. Therefore, the relationship between intellectual property right mechanisms, technology management strategies, and the subsequent performance needs to be investigated [29,30].

In this study, we aim to understand the types of negative perceptions of large R&D-intensive firms regarding patents, and we identify the resulting strategies and performance of their technology management efforts. Strategies for building up or commercializing technological capabilities are considered as technology management strategies. In addition, technology management performance is measured by the 'degree of technical, commercial, and economic success', 'diversity of technologies in a new product', and 'total turnover'.

We used survey data from the top 200, large, R&D-intensive firms in Korea. Korea is regarded as an innovative representative of East Asian countries [31], and many Korean firms have attempted to protect their innovative technologies through patents. However, not all Korean firms are active in patenting. To investigate the relationship between two sets of multiple categorical variables describing different levels of negative perceptions toward patents and the strategies and performance pertaining to technology management, we apply a categorical canonical correlation analysis (CCA). The results are useful to understand why large R&D-intensive firms do not apply for patents, identify the factors influencing the resulting strategies and performance of their technology management efforts, and establish a patent strategy for these firms.

The remainder of this study is organized as follows. In Section 2, we provide the theoretical background. In Section 3, we introduce the survey data and our methodology. In Section 4, by applying both the CCA and quantification method II to our data, we present our empirical results. In Section 5, we present our discussion and main conclusions.

2. Theoretical Background

According to the TPB, behavioral beliefs, normative beliefs, and control beliefs serve to guide human behavior [32,33]:

> "*Behavioural beliefs* are defined as beliefs about the consequences of particular behaviour and they produce a favourable or unfavourable *attitude toward the behaviour*; *Normative beliefs* are beliefs about normative expectations of relevant others and they result in perceived social pressure or *subjective norm*; and *Control beliefs* are beliefs about the presence of factors

> that may facilitate or impede performance of the behaviour and they give rise to *perceived behavioural control*, the perceived ease or difficulty of performing the behaviour."

In sum, attitude toward the behavior, subjective norms, and perceived behavioral control result in the formation of a behavioral intention [32,33]. This theory has been applied to understand a person's intention to engage in a particular behavior [34], including smoking [35], using cannabis [36], engaging in physical activity or exercise [37], and using information technology [38].

In recent times, TPB's application has been extended from individual concerns to those of organizations, such as entrepreneurial intention and behavior [39]. Delmar and Wiklund [40] used TPB to investigate the influence of small business managers' growth motivation on business growth. The authors elaborated that "the growth motivation of a small business manager is defined as the aspiration to expand the business, which is based on both attitudes and subjective norms in Ajzen's TPB, and influences manager's choice to expand the business and the willingness to sustain this choice over time". Sharma et al. [41] applied TPB to study family firms' characteristics that influence succession-planning activities. Dennis et al. [34] hypothesized that the CEO's economic attitude, perceived political pressure, personal moral obligation, perceived behavioral control, and self-identity with corporate philanthropy have a positive relation with a firm's level of corporate philanthropy. Koropp et al. [42] investigated the impact of perceived family norms, attitudes, and perceived behavioral control on family firms' financing. TPB has also been applied to explain environmental managers' behavioral intention to engage in source reduction activities in manufacturing facilities in the United States [43] as well as the environmental ethical decision making of managers in the US metal finishing industry [44].

In this study, we focus on negative perceptions toward patents, which have drawn relatively less attention than positive perceptions, and apply TPB to explore the relationship between the negative perception of patents, technology management strategies, and subsequent performance. However, an important point to be noted is that we use TPB only to understand this relationship, and we do not test it empirically.

We consider that (1) decision makers having a negative perception toward patents can produce unfavorable attitudes toward patent activity (behavioral beliefs); (2) decision makers' negative perceptions toward patents or patent activity are affected by the negative opinion about patents or patent activity of relevant competitors or other firms (subjective norm); and (3) decision makers' negative perceptions toward patents or patent activity give rise to a low level of perceived behavioral control in performing patent activity (perceived behavioral control).

If a firm's decision makers are unwilling to disclose the technical information required when applying for a patent, then they tend to not protect their technologies with patents. The decision makers may think that they do not derive any benefit from protective patents because relevant competitors or other firms can easily imitate their technology based on the released patent information. These firms prefer to protect their technological knowhow through trade secrets [19] and may want to utilize closed strategies for technological development or commercialization. In addition, if their R&D collaborators do not want to apply for a patent for an invention obtained through collaboration, the decision makers do not perform patent activity because they are concerned about discouraging future R&D collaboration with external entities. Such firms may prefer to engage in open innovation with external resources to develop or commercialize technology. Moreover, if firms lack resources, including professional human resources and funding (e.g., inability to pay considerable costs of patenting, transaction, and patent litigation or inability to monitor and enforce patents), they perceive difficulties in performing patenting activities and, consequently, tend to not protect their technologies with patents [3,45,46]. These firms may prefer to conduct open innovation strategies or licensing.

In sum, the decision maker's *attitude* toward a patent or patent activity, the *subjective norm*, and *perceived behavioral control* are connected to the formation of a patenting intention about whether or not to secure a patent. This intention of firms' decision makers is significantly related to the decision-making process of developing technology management strategies.

Many previous studies claimed that market/technological constraints and resource limitations affect decision makers' strategizing [47–49]. The influence of these environmental forces can be alleviated by decision makers' "knowledge vision, passion, accumulated experience, and propensity to innovation" [27,50,51]. The decision makers' cognitive processes and environmental forces affect each other, and both have an influence on strategy selection [27,52–54]. In this study, by focusing on decision makers' cognitive processes, we hypothesize the following:

Hypothesis 1 (H1). *The decision makers' patenting intention about whether or not to secure a patent is related to the selection of technology management strategies.*

The selection of a strategy affects firm performance, and many studies have investigated this relationship. According to Cohen et al. [55], 1478 firms on the US S&P (Standard and Poor's 500 stock market index) reported that patent applications, trade secrets, and shorter lead times are important strategies. Firms adopted a patent strategy to block competitors from certain technological areas in the discrete product industry in order to acquire a better position through bargaining in the complex product industry. In addition, trade secrets enable firms to protect their inventions by preventing imitation [19,56]. There have been many studies on R&D spending strategies, and nearly all have found that R&D spending has a positive effect on a firm's productivity growth, number of patents, and number of new products [1,9,21,22]. In this study, we hypothesize the following:

Hypothesis 2 (H2). *The selection of technology management strategies is associated with a firm's performance.*

3. Materials and Methods

3.1. Data

This study used a survey questionnaire developed by Granstrand and his team members in order to understand a firm's status and level of awareness regarding intellectual property [57]. The survey consists of (1) background information of firms; (2) items related to innovation and intellectual property management; (3) items related to technology acquisition and commercialization; and (4) items related to patents, licensing, and financing. It also includes questions regarding negative perceptions, strategies, and performance related to patents, as displayed in Appendix A. Most of the variables concerning negative perceptions, strategies, and performance are measured using a five-point Likert-type scale, which is one of the most commonly used scales. Only one question (C. (1) in Appendix A) is measured using a 10-point Likert-type scale in order to identify the share of the R&D and innovation projects' contribution to technical success, commercial success, and economic success.

We used survey data obtained from the top 200 large firms in Korea sorted by R&D expenditure in 2009 (the surveyed companies were arranged after consultation with a Swedish research team in a Korea–Sweden research exchange project). These firms spent an average of 78,276,204 euros (±388,990,212 euros) on R&D in 2009. Large firms are defined as those having more than 50 million euros in turnover or more than 250 employees. The ranking data based on R&D expenditures in 2009 were taken from the KISVALUE database [58], which is managed by the National Information and Credit Evaluation Corporation.

Our survey was conducted between September 2011 and February 2012. First, we sent e-mails to the top 200 large firms. As several firms did not respond to our survey questionnaire, we contacted the respondents by telephone and followed up with a personal visit to increase the response rate. The Korea Intellectual Property Council (KIPA) and the Small and Medium Business Administration (SMBA) helped increase the response rate of our survey further. Fifty-three out of the top 200 large firms participated in the survey, and 72 questionnaires were collected, resulting in a response rate of 27%. Eleven large firms returned more than one questionnaire filled out by respondents belonging to different departments, and we used all the returned questionnaires. After excluding questionnaires having missing values for any variable, 65 of the 72 questionnaires were considered valid. The respondents comprised 13 R&D managers, 16 general managers, and 36 others (engineers and managers), who have decision-making authority over R&D. In addition, the respondents were sufficiently knowledgeable about the items asked in the questionnaire. The companies comprised seven chemistry, biotechnology, and pharmaceutical companies; three construction companies; 30 electronics, IT, and electric power companies; 13 mechanical companies; and 10 other companies.

3.2. Method

CCA is a method of analyzing multivariate data to explain the relationship between two sets of multiple variables. The method finds that linear combinations of multiple variables in each set are highly correlated [59]. In our study, perceptions regarding patents, technology management strategies, and performance each comprise various levels. CCA was employed to test the relationship between two sets of multiple categorical variables describing the different levels of negative perceptions, strategies, and performance. We derived canonical coefficients from the CCA results and investigated the frequency of variable levels.

In this study, some variables contain many levels to interpret the relationship between them. Therefore, we rearranged the levels currently used in the Likert scale into two levels to better convey the results of our analysis: the five and 10 levels of variables were re-grouped into low and high levels based on their meaning. On a five-point Likert-type scale used for the perception- and strategy-related variables, '1' means 'not at all important' and '5' means 'very important'. We grouped '1 (not at all important)', '2 (not very important)', and 'no response' as low level, while '3 (neutral)', '4 (somewhat important)', and '5 (very important)' were classified as high level. On a five-point Likert-type scale used for the performance-related variables, we grouped '−2 (major decrease)' and '−1 (decrease)' as low level, while '0 (no change)', '+1 (increase)', and '+2 (major increase)' were classified as high level. The proportions of '3 (neutral or no change)' and 'no response' are very low; therefore, the results of our analysis are not expected to change when 'neutral' or 'no response' are set as the other group. On a 10-point Likert-type scale used for the performance-related variables, if the share of R&D and innovation projects that contributed to performance success was lower than 30%, it was classified as low level. Otherwise, it was classified as high level. We attempted to divide the number of groups into half and consequently chose 30% as the threshold.

The quantification method allows a multidimensional analysis of qualitative data [60–62]. There are four quantification methods. The first is associated with a general linear model and applied to a quantitative external criterion. The second is related to the CCA and is applied to a qualitative external criterion. The third is associated with correspondence analysis and is applied to the case in which an external criterion does not exist and response patterns of people (or things) on some attributes exist. The fourth is related to multidimensional scaling and is also applied to the case in which an external criterion does not exist and similarities between people (or things) exist [63,64]. Among the four quantification methods, we selected the second, that is, quantification method II, because it predicts the qualitative response variables based on the information regarding each subject's qualitative level [63–65] and also investigates each level's effect on the discrimination between the response variables [63].

4. Results

We conducted two consecutive CCAs between negative perceptions and strategies and between strategies and performance for all the surveyed firms. A structural equation model (SEM) could have been used instead of two consecutive CCAs if a sufficiently large sample existed. We found that there is only one significant canonical correlation between the negative perceptions on patents and technology management strategies and between the strategies and performance of technology management at the 10% level, as displayed in Tables 1 and 2.

Table 1. Results of the Canonical Correlation Analysis (Negative Perceptions and Strategies).

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Eigenvalues of Inv(E)*H				Test of H0: The Canonical Correlations in the Current Row and All that Follow Are Zero				
					Eigenvalue	Difference	Proportion	Cumulative	Likelihood Ratio	Approximate F Value	Num DF	Den DF	*p*-Value
1	0.855	0.777	0.034	0.731	2.716	1.155	0.346	0.346	0.007	1.33	195	392.88	0.010
2	0.781	0.643	0.049	0.609	1.561	0.252	0.199	0.544	0.025	1.09	168	371.32	0.240
3	0.753	.	0.054	0.567	1.309	0.580	0.167	0.711	0.064	0.94	143	348.75	0.672
4	0.649	0.496	0.072	0.422	0.729	0.296	0.093	0.803	0.147	0.76	120	325.17	0.961
5	0.550	0.309	0.087	0.302	0.433	0.142	0.055	0.858	0.255	0.65	99	300.57	0.994
6	0.475	.	0.097	0.226	0.291	0.018	0.037	0.895	0.365	0.59	80	274.95	0.997
7	0.463	.	0.098	0.215	0.274	0.063	0.035	0.930	0.471	0.56	63	248.29	0.996
8	0.417	.	0.103	0.174	0.211	0.045	0.027	0.957	0.600	0.50	48	220.56	0.997
9	0.377	.	0.107	0.142	0.166	0.079	0.021	0.978	0.727	0.43	35	191.73	0.998
10	0.282	0.093	0.115	0.080	0.087	0.024	0.011	0.989	0.847	0.33	24	161.68	0.999
11	0.244	.	0.118	0.059	0.063	0.049	0.008	0.997	0.920	0.26	15	130.15	0.997
12	0.118	.	0.123	0.014	0.014	0.006	0.002	0.999	0.978	0.13	8	96	0.998
13	0.088	.	0.124	0.008	0.008		0.001	1.000	0.992	0.13	3	49	0.943

Table 2. Results of the Canonical Correlation Analysis (Strategies and Performance).

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Eigenvalues of Inv(E)*H				Test of H0: The Canonical Correlations in the Current Row and All that Follow Are Zero				
					Eigenvalue	Difference	Proportion	Cumulative	Likelihood Ratio	Approximate F Value	Num DF	Den DF	*p*-Value
1	0.757	0.674	0.053	0.573	1.339	0.915	0.530	0.530	0.153	1.35	78	259.74	0.042
2	0.546	0.199	0.088	0.298	0.425	0.044	0.168	0.698	0.357	0.92	60	223.86	0.648
3	0.525	.	0.091	0.276	0.381	0.147	0.151	0.848	0.509	0.81	44	185.59	0.788
4	0.436	.	0.101	0.190	0.234	0.112	0.093	0.941	0.703	0.61	30	144.50	0.941
5	0.330	.	0.111	0.109	0.122	0.095	0.048	0.989	0.868	0.41	18	100	0.983
6	0.162	−0.111	0.122	0.026	0.027		0.011	1.000	0.974	0.17	8	51	0.994

Next, we calculated the quantification values based on the significant canonical correlations. In quantification method II, the quantification value's sign (plus or minus) and range provide important information [63,65], as displayed in Tables 3 and 4. We selected variables with a range exceeding 0.7 or range weight exceeding 10%, as highlighted in yellow in Tables 3 and 4. Thereafter, we interpreted the quantification values for the levels of the selected variables in the following manner: (1) we related the levels for the two variables with those associated with high positive quantification values (plus sign) and (2) related the same levels with those associated with negative quantification values (minus sign). The results for the categorical CCA are summarized in Figure 1.

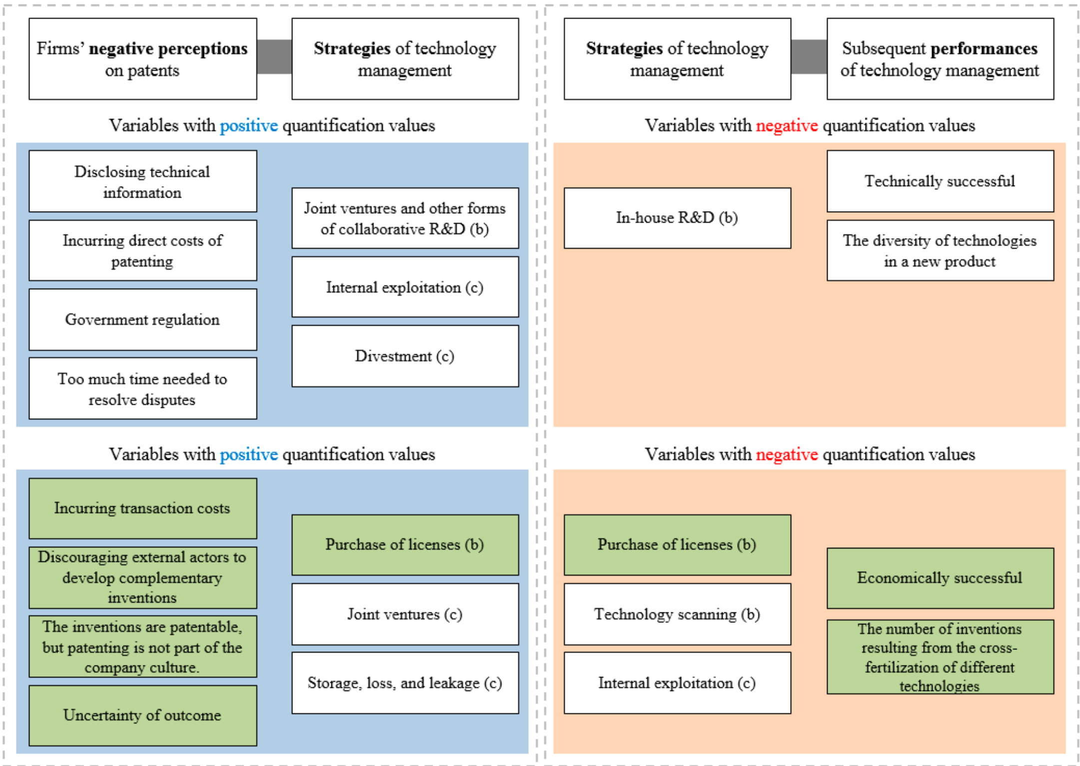

Figure 1. Summary of results of the categorical Canonical Correlation Analysis (CCA). (b: Strategies for building up technological capabilities; c: Strategies for commercializing technological capabilities).

First, we analyzed the relationship between the negative perception on patents and technology management strategies. Based on the variables with high positive quantification values as highlighted in blue in Table 3, we found that the following perceptions important in the decision not to patent and technology management strategies are related:

'Disclosure of technical information' (high level with 0.209 quantification value); 'The burdensome cost of patenting' (high level with 0.426 quantification value); 'Government regulations of anti-competitive concerns' (high level with 0.425 quantification value); and

'Too much time needed to resolve disputes' (high level with 0.279 quantification value); as well as:

'Joint ventures and other forms of collaborative R&D' (high level with 0.131 quantification value) as strategies for building up technological capabilities and 'Internal exploitation' (high level with 0.222 quantification value) and 'Divestment' (high level with 0.341 quantification value) as strategies for commercializing technological capabilities.

Table 3. Results of the Quantification Method Analysis (Negative Perceptions and Strategies).

Class of Variables	Variables	Level	Freq.	Quantification Value	Range Value	Weights of Range
Perception factors	**Disclosing technical information**	low	9	−1.300	1.509	11.43%
		high	56	0.209		
	Incurring direct costs of patenting	low	16	−1.303	1.729	13.10%
		high	49	0.426		
	Incurring transaction costs	low	12	0.858	1.053	7.98%
		high	53	−0.194		
	Discouraging R&D collaboration with other companies/organizations	low	15	0.224	0.292	2.21%
		high	50	−0.067		
	Discouraging R&D collaboration with external individuals	low	14	0.258	0.329	2.49%
		high	51	−0.071		
	Discouraging external actors to develop complementary inventions	low	12	0.823	1.010	7.65%
		high	53	−0.186		
	Inability to monitor patents	low	17	0.383	0.519	3.93%
		high	48	−0.136		
	Inability to enforce patents if/when infringed	low	26	0.094	0.156	1.19%
		high	39	−0.063		
	The company's inventions are not patentable.	low	24	0.195	0.309	2.34%
		high	41	−0.114		
	The inventions are patentable, but patenting is not part of the company culture.	low	26	0.782	1.304	9.88%
		high	39	−0.521		
	Government regulation(s)	low	18	−1.109	1.534	11.62%
		high	47	0.425		
	High costs of dispute resolution	low	20	−0.270	0.390	2.95%
		high	45	0.120		
	Too much time needed to resolve disputes	low	20	−0.629	0.908	6.88%
		high	45	0.279		
	Uncertainty of outcome	low	17	1.470	1.990	15.08%
		high	48	−0.521		
	Low damages if/when awarded	low	34	−0.080	0.167	1.26%
		high	31	0.087		
Strategy factors	In-house R&D (b)	low	5	−0.411	0.445	4.50%
		high	60	0.034		
	Acquisition of innovative firms (b)	low	17	−0.006	0.008	0.08%
		high	48	0.002		
	Joint ventures and other forms of collaborative R&D (b)	low	11	−0.645	0.776	7.86%
		high	54	0.131		
	Purchase of licenses (b)	low	19	0.526	0.743	7.53%
		high	46	−0.217		
	Other forms of technology purchase (b)	low	14	0.386	0.492	4.99%
		high	51	−0.106		
	Technology scanning (b)	low	10	−0.238	0.281	2.85%
		high	55	0.043		
	Internal exploitation (c)	low	8	−1.578	1.800	18.22%
		high	57	0.222		
	Creation of innovative firms (c)	low	14	−0.146	0.186	1.88%
		high	51	0.040		
	Joint ventures (c)	low	11	2.109	2.539	25.70%
		high	54	−0.430		
	Sales of technology licenses (c)	low	12	−0.379	0.465	4.71%
		high	53	0.086		
	Other forms of technology sales (c)	low	11	−0.083	0.100	1.01%
		high	54	0.017		
	Divestment (c)	low	24	−0.583	0.924	9.36%
		high	41	0.341		
	Storage, loss, and leakage (c)	low	20	0.773	1.116	11.30%
		high	45	−0.344		

Note: Technology strategies can be divided into (a) strategies for building up technological capabilities and (b) strategies for commercializing technological capabilities.

Next, the analyses of variables with negative quantification values as highlighted in red in Table 3 showed that the following perceptions and strategies are related:

'The burdensome costs of transaction costs' (high level with −0.194 quantification value);

'Discouraging R&D collaboration with external actors' (high level with −0.186 quantification value); 'Non-patenting culture' (high level with −0.521 quantification value);

'Uncertainty of outcome of patent litigation' (high level with −0.521 quantification value); as well as:

'Purchase of licenses' (high level with −0.217 quantification value) as strategies for building up technological capabilities and 'Joint ventures' (high level with −0.430 quantification value) and 'Leaked technology information' (high level with −0.344 quantification value) as strategies for commercializing technological capabilities.

Table 4. Results of the Quantification Method Analysis (Strategies and Performance).

Class of Variables	Variables	Level	Freq.	Quantification Value	Range Value	Weights of Range
Strategy factors	**In-house R&D (b)**	low	5	−1.407	1.524	17.48%
		high	60	0.117		
	Acquisition of innovative firms (b)	low	17	−0.515	0.698	8.00%
		high	48	0.182		
	Joint ventures and other forms of collaborative R&D (b)	low	11	0.516	0.622	7.13%
		high	54	−0.105		
	Purchase of licenses (b)	low	19	0.559	0.790	9.06%
		high	46	−0.231		
	Other forms of technology purchasing (b)	low	14	−0.375	0.478	5.48%
		high	51	0.103		
	Technology scanning (b)	low	10	1.199	1.417	16.25%
		high	55	−0.218		
	Internal exploitation (c)	low	8	0.805	0.918	10.53%
		high	57	−0.113		
	Creation of innovative firms (c)	low	14	0.233	0.297	3.40%
		high	51	−0.064		
	Joint ventures (c)	low	11	0.404	0.486	5.58%
		high	54	−0.082		
	Sales of technology licenses (c)	low	12	0.387	0.474	5.44%
		high	53	−0.088		
	Other forms of technology sales (c)	low	11	0.140	0.169	1.94%
		high	54	−0.029		
	Divestment (c)	low	24	−0.249	0.395	4.53%
		high	41	0.146		
	Storage, loss, and leakage (c)	low	20	0.312	0.451	5.17%
		high	45	−0.139		
Performance factors	**Technically successful**	low	39	−0.304	0.761	6.36%
		high	26	0.456		
	Successfully brought to the market and/or used	low	41	0.020	0.055	0.46%
		high	24	−0.035		
	Economically successful	low	43	0.349	1.030	8.62%
		high	22	−0.682		
	Diversity of technologies in a new product	low	2	−4.399	4.539	37.98%
		high	63	0.140		
	Number of inventions resulting from the cross-fertilization of different technologies	low	4	5.197	5.538	46.34%
		high	61	−0.341		
	Total turnover	low	6	−0.026	0.029	0.24%
		high	59	0.003		

We also interpreted the relationship between technology management strategies and performance. Analysis of the relationship between the variables with high positive quantification values as highlighted in blue in Table 4 showed that 'In-house R&D' (high level with 0.117 quantification value) as a strategy for building up technological capabilities is associated with 'Diversity of technologies in a new product' (high level with 0.140 quantification value) and 'More than 30% technical success of R&D and innovation projects' (high level with 0.456 quantification value). Next, the analyses of variables with negative quantification values as highlighted in red in Table 4 showed that 'Purchase of licenses' (high level with −0.231 quantification value) and 'Technology scanning' (high level with −0.218 quantification value) as strategies for building up technological capabilities and 'Internal exploitation' (high level with −0.113 quantification value) as a strategy for commercializing technological capabilities are related to 'The increase in number of inventions resulting from the cross-fertilization of different technologies' (high level with −0.341 quantification value) and 'More than 30% economic success of R&D and innovation projects' (high level with −0.682 quantification value).

Lastly, we interpreted the relationship between a firm's negative perceptions toward patents, strategies of technology management, and subsequent performance. The important factors influencing the decision not to patent, such as 'The burdensome transaction costs,' 'Discouraging cooperation with external actors that develop complementary inventions', 'Non-patenting culture', and 'Uncertainty of outcome of patent litigation', are associated with 'Purchase of licenses' as strategies for building up technological capabilities. In addition, this strategy is related to 'The increase in the number of inventions resulting from the cross-fertilization of different technologies' and 'Economic success'.

5. Discussion

Many firms consider R&D and patenting activities as methods to improve their competitiveness. However, not all results of R&D activities are patented. This may be partly due to firms' negative perceptions regarding patents. This study investigated the relationship between firms' negative perceptions toward patents and their strategies of technology management, as well as that between the strategies and performance of technology management.

We considered that both positive and negative aspects of patents are significantly associated with a firm's perception regarding patents as well as the associated technology management strategies and subsequent firm performance. We focused on the negative aspects of patents, which have drawn relatively less attention than the positive aspects, to understand the main reasons why large R&D-intensive firms did not engage in patent activity. Many previous researchers have applied TPB to understand an individual's intention to engage in a specific behavior. In recent times, TPB has been applied to entrepreneurial intentions and the behavior of small businesses or family firms. In this study, we applied the TPB to explain the intentions and behavior of decision makers for large R&D-intensive firms in Korea. Based on the related literature, we hypothesized as follows: (H1) The decision makers' patenting intention about whether or not to secure a patent is related to the selection of technology management strategies; and (H2) The selection of technology management strategies is associated with a firm's performance. These two hypotheses are empirically supported for large R&D-intensive firms in Korea, as shown in the Tables 3 and 4 and Figure 1. Based on the results of our hypothesis testing, the relationship among negative perceptions, strategies selection, and performance can be summarized as follows: the negative perception variables, including 'Burdensome transaction costs', 'Discouraging cooperation with external actors', 'Non-patenting culture', and 'Uncertainty of outcome of patent litigation' are related to the strategy variable 'Purchase of licenses' and the performance variables 'Increase in the number of inventions' and 'Decrease in the diversity of technologies in a new product'.

In Korea, the market for technology transfers has not matured; therefore, finding a transfer partner is not easy for many firms. In case of a collaborative R&D project, it can be very difficult to evaluate the contribution of each stakeholder toward inventions. In addition, R&D collaboration partners may want to protect their inventions through commercial confidentiality rather than through patents. Further, patent litigations can take a long time to settle, and the loss due to patent infringement cannot be properly compensated by statutory damages. These issues affect firms' perceptions on patents. Accordingly, firms prefer to purchase a license, rather than apply for a patent. In this context, the government needs to create an innovation ecosystem in order to encourage firms to apply for a patent for their patentable inventions.

The findings of this study are expected to support technology management decisions when a firm having negative perception toward patents and/or patenting selects strategies for building up or commercializing its technological capabilities.

However, our study has two limitations. First, the size of the sample in this study is small. Second, we only considered Korean firms. As a larger data set becomes available, CCA can be conducted by industry and country. A follow-up study is also needed to compare large R&D-intensive firms with small and medium R&D-intensive firms in terms of their perceptions regarding patents, subsequent strategies, and technology management performance. These are directions for future research.

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Author Contributions: Eun Jin Han reviewed the related literature, conducted the analysis, interpreted the results, and wrote the manuscript. So Young Sohn designed the study, outlined the methodology, and helped to draft the paper. Both authors have read and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. The Survey Questionnaire

A. Negative perception

(1) How important are the following reasons for your company to decide not to patent? (scale: 1 = not at all important; 5 = very important)

- (a) Disclosing technical information
- (b) Incurring direct costs of patenting
- (c) Incurring transaction costs
- (d) Discouraging R&D collaboration with other companies/organizations
- (e) Discouraging R&D collaboration with external individuals
- (f) Discouraging external actors to develop complementary inventions
- (g) Inability to monitor the patents (e.g., regarding infringements)
- (h) Inability to enforce the patents if/when infringed
- (i) The company's inventions are not patentable
- (j) The inventions are patentable, but patenting is not part of the company culture

(2) How important are the following problems for your company's ability to enforce its patents? (scale: 1 = not at all important; 5 = very important)

- (a) Government regulation
- (b) High costs of dispute resolution
- (c) High time consumption of dispute resolution
- (d) Uncertainty of outcome
- (e) Low damages if/when awarded

B. Technology management strategy

(1) How important are the following strategies for building up the technological capabilities for your company? (scale: 1 = not at all important; 5 = very important)

(a) In-house R&D (incl. recruitment and training)
(b) Acquisition of innovative firms (or business units)
(c) Joint ventures and other forms of collaborative R&D
(d) Purchase of licenses
(e) Other forms of technology purchase (e.g., contract R&D)
(f) Technology scanning

(2) How important are the following strategies for commercializing the technological capabilities of your company? (scale: 1 = not at all important; 5 = very important)

(a) Internal exploitation (direct investment in production and/or marketing and sales of technology-based products and services)
(b) Creation of innovative firms (e.g., units, spin-offs)
(c) Joint ventures
(d) Sales of technology licenses
(e) Other forms of technology sales (e.g., performing contract R&D)
(f) Divestment
(g) Storage, loss, and leakage

C. Technology management performance

(1) What share of the R&D and innovation projects in your company eventually becomes

(a) Technically successful (the project leads to a functioning technology)?

☐ 0%–9% ☐ 10%–19% ☐ 20%–29% ☐ 30%–39% ☐ 40%–49% ☐ 50%–59% ☐ 60%–69% ☐ 70%–79% ☐ 80%–89% ☐ 90%–100%

(b) Commercially successful (the resulting technology is sold and/or used internally)?

☐ 0%–9% ☐ 10%–19% ☐ 20%–29% ☐ 30%–39% ☐ 40%–49% ☐ 50%–59% ☐ 60%–69% ☐ 70%–79% ☐ 80%–89% ☐ 90%–100%

(c) Economically successful (the project gives a positive return on investment)?

☐ 0%–9% ☐ 10%–19% ☐ 20%–29% ☐ 30%–39% ☐ 40%–49% ☐ 50%–59% ☐ 60%–69% ☐ 70%–79% ☐ 80%–89% ☐ 90%–100%

(2) Please indicate whether the trends in the statements below have been decreasing or increasing during the last five years (scale: −2 = major decrease; 0 = no change; +2 = major increase).

(a) The diversity of technologies in a new product from my company has typically decreased/increased.
(b) The number of inventions resulting from the cross-fertilization of different technologies in my company has decreased/increased.
(c) The total turnover in my company has decreased/increased.

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