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A Study on Technology Development Performance and Technology Commercialization Performance According to the Technology Development Capability of SMEs Focusing on a Comparative Analysis of Technology Business Groups

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Abstract: Recently, a lot of small- and mid-sized companies have emerged through continuous technological development and start-up successes despite insufficient scales and resources compared to medium companies or conglomerates in fierce market competition. Technological development capability, which is required to acquire, select, or utilize source technology for company competitiveness, becomes the competitive edge and key capability to gain distinctiveness. Accordingly, the objective of this research was to investigate the influential factors on performance by suggesting technological development results and technology commercialization as the outcome of technological development capability and to identify the capability required for successful technological development performance and technology commercialization for companies through previous academic research. Moreover, the study aimed to investigate performance differences according to technology business groups by dividing the groups into high-technology companies, medium-technology companies, and low-technology companies. As a result of the analysis, among the indicators constituting technological development capability, manpower in technological development and technological development-specialized research centers had a positive influence on the product competitiveness of technological development performance. Also, technological development expenses and technology skill levels were verified to have positive impacts on the technology competitiveness of technological development performance. As for technology commercialization performance, the more manpower that is in research and development, the higher the sales amounts by technological development; also, the higher the technology skill levels, the higher the export amounts by technological development. Moreover, technology business groups had differences in performance. This research has significance in focusing on the influence of the technological development capability of companies on technological development performance and technology commercialization performance. Future research is expected to draw new variations different from the analysis results from existing studies by setting variations, investigating complementary relationships among variations in detail, and utilizing statistical techniques that can control mutual relationships among variations.

Keywords: technology development performance; technology commercialization; SMEs

1. Introduction

In recent years, there have been a number of SMEs that continue to make technological developments and start to succeed even in a highly competitive market. As the importance of

SMEs grows, the needs of SMEs are also important, but their capability is important in terms of how to use the resources efficiently and effectively [1,2]. In order to overcome the complex and rapidly changing environment, the importance of technology development capability, which is an intangible asset, has been raised. Among the various competencies of companies, the technology development capability to acquire, select, and utilize technology that is a source of corporate competitiveness is the core competence of having a competitive advantage and differentiation. Because technology development capability is complex and implicit, it can prevent imitation from competitors and promote growth of the company.

Research on technology development capability and performance is research that is interested in each government or research institute because it affects the important influence on the company continuously investing in technology development. Many studies have attempted to prove what kind of results are produced by companies according to their technology development capability, and whether they actually show the results in business management. Research on the measurement of technology development performance, that is, on the factors that constitute the capability of technology development, has been continuously studied from the point of view of how such factors influence the performance of the company in detail and business performance.

However, in most studies, the performance of technology development is focused on the success of technology development in one dimension. However, it is necessary to examine the success of technology commercialization step by step because it includes the process from commercialization to commercialization so that it can be sold to the market through production of the prototype after the success of technology development.

In this study, we present the results of technology development and technical commercialization as a result of technology development capability to analyze the importance of the technology development capability of SMEs. Whether technology development capability actually affects technological development performance and technical commercialization performance and how much and whether they have influence will also be investigated.

The composition of this study is as follows. In the introduction, the background and purpose of this study and the contents of the study are summarized. The theoretical background and prior studies are summarized as research on technology development capability, technology development performance, and technical commercialization performance. In the study method, two hypotheses were set up and a model was suggested. In addition, the research method for verifying the research hypothesis, the data collection, and the operational definition of the variables is presented. The results of the study showed the results of logistic regression analysis and multiple regression analysis for the hypothesis verification as well as the basic statistical analysis. Finally, the conclusions of previous research are summarized, and implications and limitations of this study are presented.

The implications of this study are as follows. First, the effect of technology development capability on technology development performance and technology commercialization performance was proved through empirical data. This study analyzed the factors that influence the technology development performance and technology commercialization performance. Second, the results of technology development capability were reviewed in a multi-dimensional aspect as quantitative and qualitative indicators. In a previous study, performance based on technology development capability was analyzed using only quantitative indicators. On the other hand, this study has a significant effect in that the technology development performance is composed of subjective and qualitative indicators, and the technology commercialization performance is composed of objective and quantitative indicators. Third, this study was based on a comparative analysis of technology companies. Most of the existing research has been conducted by high-tech companies. Therefore, this study is meaningful in that it is divided into high-technology companies, medium-technology companies, and low-technology companies.

2. Literature Review

2.1. Technology Development Capability

In order to define the concept of technology development capability, it is necessary to analyze various concepts, such as technology innovation capability and R&D capability [3]. Westphal and Dahlman defined technology innovation capability as a capability to effectively utilize existing technology knowledge. Kim [4] defined the capability to acquire and utilize existing technologies, as well as the capability to create new ones. Recently, it has been suggested that the concept of technological innovation capability should be included not only at a technical level but also at the organizational management level of a company. Ha Tae-Jeong defined technological capability as technology investment capability, production capability, and technological innovation capability, and these three definitions mean that they are integrated into each other rather than being divided into individual domains [5]. The R&D capability is described as a key factor in achieving the best business performance in the marketplace. In addition, R&D capability includes research and development activities as well as learning capability [6].

Cavusgil and Knight argue that technology development capability is a special intangible asset of a company. It is a resource that can overcome various constraints when a company enters the overseas market. It is a monopolistic and discriminative resource. Hymer and Caves argue that technology development capability, which is one of the internal capabilities of the company, is accumulated through continuous investment of the company, and thus it is not only a source of competitiveness but also a motive for internationalization. In other words, technology development capability prevents imitation from competitors, enhances competitiveness of companies, and the complexity and implicit nature of production techniques inherent within the company make it difficult for competitors to steal.

This study defined technology development capability as 'capability related to the technology possessed by the company' by broadly including the meaning of technology innovation capability and R&D capability based on previous studies.

2.2. Technology Development Performance

Technology development performance can be defined as the technology acquired during the course of a technical development project. Technology development performance can be explained by a similar concept to R&D performance [7]. Cohen and Levinthal argue that R&D performances are defined as "original knowledge created in research and development process" and mean an improvement of the production process. In addition, commercialization of commodities is included [8].

Technology development performance is generally direct and made up of short-term primary outcomes. Secondary performance refers to both indirect and long-term patents and prototypes. Lee Gil-Woo divided secondary performance into sales growth, cost reduction, human resource development [9], and quality improvement. Ryu Ku-hwan regarded R&D performances and management performance as the same concept and constructed R&D performance factors [10]. It is necessary to identify the actual performances and investigate the relationship between them, because the performance of a company is not simply measured in a single dimension but has a multidimensional aspect and correlation [11].

Most previous research has prioritized financial performance in analyzing the performance of a company. However, rather than merely emphasizing financial performance, research should be undertaken in a diverse and balanced manner. Lee Hyung-mo analyzed the relationship between technical performance, organizational performance, product performance, customer performance, and financial performance indicators [12].

In this study, technology development performance was defined as "direct and short-term outcomes that can be acquired in the process of technology development." However, it did not include the commercialization process.

2.3. Technology Commercialization

Technology commercialization has been defined variously through the laws and scholars of each country. In addition, the concept of technology commercialization is defined variously according to the purpose of the research and the development target. Mitchell and Singhused a technique to acquire and complement ideas to enhance ideas, develop them into products, manufacture them, and sell them. Chesbrough defined technology commercialization as a process of promoting the use of all the various technologies [13–15], including internal and external, to enhance the efficiency of the company's innovation. Lim Ho-sun defined technology commercialization as the process of commercialization of products, processes, and services using technology to enable new product development and an improvement of existing products [11]. Technology commercialization can be defined as a process leading to production through the development of new products and new processes through actual utilization of R&D performances, or improvement of existing products and processes [16]. Choi Jong-In defined technology commercialization as the process of making developed technologies to be marketed through commercialization [17]. In addition, Lee said that technology commercialization is linked with each stage of R&D to acquire ideas, improve ideas through complementation [9], manufacture products that can be commercialized, and sell in the market. Choi Yoon-jung defined the activities and processes to create new markets by adding ideas to developed technologies [18].

Technology commercialization is defined in various ways, but it is clear that technology commercialization is an important process that brings direct benefits through technology development. It is not only about the success of technology development but also from the success of technology to technology commercialization [13,19–21]. In other words, ideas that include new products and services acquired from technological development performances should be converted into commercialization results faster than competitors. Technological commercialization is not only an important step in creating added value in this regard but also a driving force to gain a leading edge in an uncertain and intense market environment [22]. Therefore, technology commercialization is recognized as a key source for securing the competitiveness and development of companies, and various commercialization strategies are proposed for the success of technology commercialization.

Accordingly, this study defines technology commercialization performance as an 'indirect and long-term occurrence that results from technology success and creates value added from technology development.'

2.4. Classification of Technology Companies

Classification by possessing technology characteristics that are divided for the purpose of comparative analysis in this study is different from the technology level classification classified by an industry based on high technology, medium technology, and low technology. The three categories were defined and classified.

High technology is defined as a company possessing product innovation, process innovation, new product design technology through R&D, a patent or source technology company recognized in the global market, a technology holding company in the 6T field, and a company that commercializes basic science and technology. In addition, some advanced companies are classified into companies that compete with monopolized technology, or are domestic import substitutes, or companies with next-generation new technology capabilities that are comparable with other advanced product-related companies. Intermediate technology is defined as a company with independent product improvement, process improvement technology capability, a company that competes on the basis of medium technology in developed countries, a company with ODM and OEM production capacity, and a company with capital barrier technology as a capital-intensive technology. Low technology is defined as a generalized product in emerging industrial countries, a company with production technology, an improvement of its own product, a process improvement, a company lacking in design capability, and a company that depends on the capacity of a specific production facility in a single process [23].

3. Hypotheses

3.1. Technology Development Performance According to Technology Development Capability

Various research on the relationship between technology development capability and technological development performance has been done according to the scope and subject. Schoenecker and Swanson used R&D expenditure, R&D investment share, and technical manpower as technical capability indicators to identify the technology capability indicators of companies and analyze their performance [24]. Romijin and Alvaladejo used R&D investment per capita as a measure of technological development capability, including the amount of R&D investment per capita and the share of investment in technology development relative to sales. Acha studied the petroleum industry and found that technology development capability positively influenced business performance. In addition, Yoon Seok-cheol explains that the greater the number of technological innovations, the greater the investment and labor productivity [25,26].

The Small and Medium Business Administration conducted the "Small and Medium Business Technology Statistics Survey" [27] organized by the Small and Medium Business Administration in Korea. Among the survey items, the technology development performance was divided into 12 types, which were divided into sales growth, exports, product quality and performance improvement, production process improvement, new business, and productivity improvement.

It is expected that the relationship between these two factors will be positively related to each other according to various previous studies. Therefore, this study proposes Hypothesis 1 and verifies it as follows:

Hypothesis 1. *The technological development capability of SMEs will have a positive impact on technology development performance.*

Hypothesis 1-1. *Technological development personnel will have a positive impact on the technological competitiveness of technology development performance.*

Hypothesis 1-2. *Technology and research and development costs will have a positive impact on the technological competitiveness of technology development performance.*

Hypothesis 1-3. *The presence of a dedicated research institute for technology development will have a positive impact on the technological competitiveness of technology development performance.*

Hypothesis 1-4. *The level of technical skill will have a positive effect on the technological competitiveness of technology development performance.*

Hypothesis 1-5. *Technology development manpower will have a positive impact on the product competitiveness of technology development performance.*

Hypothesis 1-6. *Technology and research and development costs will have a positive impact on the product competitiveness of technology development performance.*

Hypothesis 1-7. *The presence of a research institute dedicated to technology development will have a positive impact on the product competitiveness of technology development performance.*

Hypothesis 1-8. *The technological skill level will have a positive effect on the product competitiveness of technology development performance.*

3.2. Technology Commercialization Performance According to Technology Development Capability

As a result of technological development capability, technology development results and technology commercialization results were presented. As a measure of technology commercialization for IT companies, Shim Tae-ho showed the price competitiveness compared with other companies, the profitability of products, the existence of technology that commercialized for the first time in the industry [28], the domestic market share of products that succeeded in technology commercialization, and so on. Zahra and Nielsen analyzed the factors that could explain the attributes of technology and analyzed the relationship between manufacturing capability and technology commercialization [24]. Park Soon-cheol used the indicators of technological performance as indicators of technology commercialization capability. Revenue and exports, which are financial indicators [29], were regarded as indicators of technology commercialization performance, and technology development capability was found to be affected.

In this study, we attempted to analyze the results of technology commercialization, which is the final stage of technological development, rather than just the result of technological development, in terms of the result of difference of technological development capability based on previous research. It is not only the success of technology development but also the stage of commercialization success as a dimension of success according to the broad definition of technology commercialization. The relationship between technological development capability and technology commercialization is expected to be positive, and Hypothesis 2 is presented as follows:

Hypothesis 2. *The technological development capability of SMEs will have a positive effect on the technical commercialization performance.*

Hypothesis 2-1. *Technological development personnel will have a positive impact on sales due to technology development.*

Hypothesis 2-2. *Technology and R&D expenses will have a positive impact on sales due to technology development.*

Hypothesis 2-3. *The presence of a research institute dedicated to technology development will have a positive impact on sales due to technology development.*

Hypothesis 2-4. *The level of technical skill will have a positive effect on sales due to technology development.*

Hypothesis 2-5. *Technological development personnel will have a positive impact on exports by technology development.*

Hypothesis 2-6. *Technology and research and development costs will have a positive impact on exports due to technology development.*

Hypothesis 2-7. *The presence of a research institute dedicated to technology development will have a positive effect on the amount of exports by technology development.*

Hypothesis 2-8. *The level of technical skill will have a positive impact on exports by technology development.*

4. Method

4.1. Data

The "2014 SME Technical Statistics Survey in Korea" was conducted in order to comprehensively grasp all the actual conditions related to technology development of SMEs and to provide basic data

necessary for establishing and promoting effective technology support policies for SMEs. The survey was based on the national approval statistics under Article 8 (Creation of Technical Statistics for Small and Medium Enterprises) and Article 18 (Approval for Statistical Preparation) of the Statistical Law of Small Business Innovation Promotion Act.

Since the enactment of the Law for the Promotion of Technology Innovation in Small and Medium Sized Enterprises, the survey was conducted for two years from 2003, and the results were announced. We surveyed 42,110 small- and medium-sized enterprises (SMEs) with technological development in industries other than manufacturing and manufacturing, with a range from 5 to less than 300 employees. In total, there were 34,257 SMEs in manufacturing, and 7853 SMEs in industries other than manufacturing. Of these, 2200 enterprises, 1779 manufacturing enterprises, and 421 enterprises other than manufacturing industry were included in the sample survey. It took place from 1 January 2013 to 31 December 2013, for one year from 26 May 2014 to 29 August 2014. Based on the interviews, the researchers used email and telephone surveys in an additional way.

Technology development organization and manpower status, status of technology test and inspection equipment, content of technology development activity, status of technology development investment, technical competitiveness grasp and degree of technology level, technical development performance, contents related to technology protection, factors, evaluation of technology development support system, etc. were used. In this study, classification by the characteristics of the technology, which is divided by the characteristics of the technology, was different from the classification by the technology level classified on the basis of high technology, medium technology, and low technology, we classified them into three categories.

4.2. Operational Definition of Variables

As a result of technological development, various indicators have been used, but economic indicators are used the most. This is because sales, market share, and profitability are the most direct indicators of company performance. However, these economic indicators can be a somewhat extensive analysis in determining the performances of technology development. In the success of technology development, various influencing factors are multidimensional, so it is difficult to identify the results of various interrelationships with a simple profit margin and sales amount. In Ji Sung-Kwon and Yang Hee-soon [30], most studies argue that only objective indicators that measure an increase in sales and profit margins should be analyzed and subjective indicators should be considered. In addition, Kim Jung-hoon and Bae Young-il proposed the necessity of deriving the relative performance level in order to measure the technological development performance while claiming the importance of subjective indicators [4,31]. Ko Bong-Sang argues that there is a problem in considering only financial indicators and constructed measurement indicators by separating financial and non-financial indicators [32]. Kang Ji-min argues for the importance of qualitative indicators as a concept equivalent to subjective indicators. It was composed of qualitative results of sales [16], time reduction, cost reduction, R&D productivity, and product innovation as qualitative indicators. Lee Doo-Myung considered non-financial performance [33], technological innovation performance, technical superiority, and customer satisfaction as a measure. Lee Bong-Kun defined technical commercialization performance as non-financial performance rather than financial performance and divided it into product competitiveness and technology competitiveness [27].

This study was divided into objective and subjective indicators as the concept of performance according to R&D capability. Technology development performance was used as a subjective indicator and technology commercialization as used as an objective indicator. The technological development performance subordinate variables were defined as technology competitiveness and product competitiveness by determining whether the technology development performance items of the SME statistics survey data were entered into the new business field and whether they were improving the product quality and performance. In addition, while focusing on technology development performance as a subjective index, technical commercialization performance composed of objective

indicators as financial indicators was also used. Among the items of technological development performance in the SME technical statistical survey, the sales by technology development and the exports by technology development, which are direct results through technology development activities, were considered as indicators.

In Schoenecker and Swanson, the scale, technology manpower, technology cooperation, R&D investment, and the number of new product launches are presented as indicators of technology capability. In addition, Romijin and Alvaladejo used the technology development investment amount and the investment ratio of technology development for sales as determining factors. Lee Byung-heon introduced the concept of input and output of technology development capability and constructed the measurement level of a technology level item as a technology input factor. In this study [34], the technology development capability, which is an independent variable, was composed of technology development manpower, technology R&D cost, and technology development research institute. Finally, we set the new technology development ability and commercialization ability, which is technical skill level, as the last independent variable of technology development capability.

5. Results

5.1. Descriptive Statistics and Correlation Matrix

As shown in Table 1, 622 low-technology companies, 1215 medium-technology companies, and 363 high-tech companies were classified as technology companies. In the comparative analysis, the ratio of low technology companies and medium technology companies became smaller, while that of high-technology companies was 23% This is a large proportion. According to industry classification, more than 80% of Korea's SMEs are based on manufacturing. Since medium-technology companies account for a large share of the total number of industries, non-manufacturing industries accounted for a large share. Compared with medium-technology companies, high-technology companies showed less importance on manufacturing than low-technology companies.

In terms of sales, sales of high-technology companies increased significantly. The higher the value of a product or service, the higher the number of high-tech companies that can expect a higher sales volume. It can be seen that the export amount is even bigger than that of the low-technology companies compared to the high-technology companies. In terms of operating profits, high-tech companies were also higher than other companies. In the three financial indicators, low-technology firms were found to be below average. In terms of added value, it is important to enhance the value of technology in order to achieve effective management performance, and it can be expected that the higher the value of the technology, the greater the performance can be expected. In addition, this study verified the difference between technology development capability, technology development performance, and technology commercialization performance according to technology companies through an analysis of variance. As a result of analyzing the differences in technology development capability, all of the remaining variables except technology development cost were significant as shown in Tables 2 and 3.

Table 1. Descriptive statistics.

Division		Total (N = 2200)		Low-Technology Companies (N = 622)		Medium-Technology Companies (N = 1215)		High-Technology Companies (N = 363)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
Scale (unit: number of employees)	5~19	926	42.09	344	55.31	455	37.45	127	34.99
	20~49	618	28.09	166	26.69	363	29.88	89	24.52
	50~99	309	14.05	63	10.13	183	15.06	63	17.36
	100~299	347	15.77	49	7.88	214	17.61	84	23.14
Company type	General Company	1009	45.86	330	53.05	558	45.93	121	33.33
	Innovation company	1191	54.14	292	46.95	657	54.07	242	66.67
Industry	manufacturing	1779	80.86	541	86.98	1003	17.45	235	64.74
	etc.	421	19.14	81	13.02	212	82.55	128	35.26
Product Life Cycle	Market entry	173	7.86	65	10.45	79	6.50	29	7.99
	growth	1169	53.14	311	50.00	639	52.59	219	60.33
	Maturity	797	36.23	211	33.92	475	39.09	111	30.58
	Decline	61	2.77	35	5.63	22	1.81	4	1.10
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Work Years		15.81	9.87	15.38	10.03	15.98	9.66	16.01	10.26
Management performance (unit: million won)	Sales	18,219	27,765	11,794	18,953	19,837	28,800	23,811	34,263
	Exports	1848.0	7858.1	744.0	3502.9	2013.6	8960.0	3185.3	8991.4
	Operating profit	1061.1	2596.7	616.4	1328.1	1107.7	2714.9	1667.2	3535.8

Table 2. Comparison of technology development capabilities, technology development performance, and technology commercialization performance according to technology companies.

Division		Total (N = 2200)	Low Technology Companies (N = 622)	Medium Technology Companies (N = 1215)	High Technology Companies (N = 363)	F
		Mean (S.D.)				
R&D workforce	R&D personnel	6.60 (10.52)	3.53 (3.96)	6.60 (9.03)	11.89 (18.11)	77.34 ***
	Total employees	49.61 (58.47)	33.78 (44.64)	53.35 (59.92)	64.25 (67.94)	37.88 ***
	R&D personnel/ Total employees	0.21 (0.20)	0.17 (0.14)	0.21 (0.20)	0.30 (0.25)	51.34 ***
Technology Development Cost (Unit: million won)	Technology Development Cost	585.59 (1096.22)	626.30 (987.36)	579.83 (1183.51)	535.13 (961.51)	0.83
	Sales	18,218.7 (27,762.9)	11,793.5 (18,953.0)	19,837.1 (28,799.8)	23,811.0 (34,263.2)	26.69 ***
	Technology Development Cost/Sales	0.12 (1.52)	0.06 (0.10)	0.09 (0.16)	0.35 (3.73)	5.08 **
A dedicated research institute	existence	1171 (53.23)	213 (34.24)	670 (55.14)	288 (79.34)	–
	Nothing	1029 (46.77)	409 (65.76))	545 (44.86)	75 (20.66)	–
Skill level (Unit: million won)	New Technology Development ability	70.22 (21.69)	66.09 (21.51)	70.17 (21.38)	77.50 (21.16)	32.60 ***
	Commercialization ability	67.07 (26.69)	62.39 (27.25)	67.88 (25.88)	72.42 (27.20)	17.68 ***
Technology development Performance (Performance exists = 1, Without Performance = 0)	Technical Competitiveness	0.10 (0.30)	0.06 (0.24)	0.10 (0.30)	0.17 (0.38)	16.14 ***
	Product competitiveness	0.65 (0.48)	0.61 (0.49)	0.67 (0.47)	0.64 (0.48)	4.13 *
Technology commercialization Performance (Unit: million won)	Sales by technology development	3808.00 (8178.26)	1942.91 (4020.41)	4308.76 (9034.86)	5327.72 (9781.64)	25.27 ***
	Exports by technology development	455.50 (2781.24)	192.92 (1145.88)	484.64 (3226.77)	807.87 (3093.95)	5.78 **

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3. Correlation matrix (Unit: million won).

	V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**
V1	1										
V2	0.015	1									
V3	0.074 ***	−0.074 ***	1								
V4	−0.411 ***	0.120 ***	−0.406 ***	1							
V5	−0.028	0.033	−0.060 **	0.093 ***	1						
V6	0.318 ***	0.141 ***	−0.127 ***	0.102 ***	0.027 ***	1					
V7	0.088 ***	0.061 **	−0.006	0.027	−0.016	0.057 **	1				
V8	0.086 ***	0.042	0.097 ***	−0.031	−0.027	0.036	0.110 ***	1			
V9	0.033	0.070 **	−0.074 ***	0.085 ***	0.070 **	0.104 ***	0.039	−0.016	1		
V10	0.478 ***	−0.020	0.075 ***	−0.159 ***	−0.026	0.178 ***	0.070 **	0.071 ***	0.048 *	1	
V11	0.193 ***	−0.032	0.046 *	−0.051 *	−0.009	0.092 ***	0.064 **	0.030	0.069 **	0.419 ***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.2. Technology Development Performance According to Technology Development Capability

The technological development performance subordinate variables were defined as technology competitiveness and product competitiveness by determining whether the technology development performance items of the SME statistics survey data had entered into a new business field and whether they were improving the product quality and performance.

In the technology competitiveness of technology development performance, as shown in Table 4, it was found that the total development cost was influenced by technology development cost, skill level, and type of company. However, when the technology group was classified, it can be concluded that the technological development capability is limited to low-technology companies. It is considered that entering the new business sector is a more multidimensional problem and does not affect medium-technology companies or high-technology companies.

As a result of logistic analysis, it was found that technology development personnel, technical research institutes, and industrial types have an effect on the product competitiveness of technology development performance as shown in Table 5. If there are a lot of personnel who are in charge of technology development and a dedicated research institute, it is reflected in the product quality and performance, and it is considered to affect the competitiveness of products because they are constantly trying to develop products. As a result of comparing the competitiveness of the products according to the technology companies, the results of the three companies showed that the technological development capability affects the product competitiveness. In the overall product competitiveness, technological development personnel and technical research institutes were found to have an influence, but as a result, technological development capability differed according to each group. The industrial type affects both the low-tech companies, medium-technology companies, and high-technology companies, and the technical capability level affects the competitiveness of the low-tech companies and the medium technology companies. Therefore, although the technological development capability of a company affects the competitiveness of the product, which is a result of technological development, the factors influencing the quality and improvement of the product depend on the type of technology. It can be seen that the factors that are necessary for the competitiveness of the product to be different according to the level of the technology that the company possesses and the performance differs depending on which part makes more effort. In other words, in order to increase the performance according to each technology group, it was proven in this study which field should be focused and developed.

Table 4. Logistic analysis result of technical competitiveness of technology development performance.

	B	Exp(B)	Low-Technology Companies EXP(B)	Medium-Technology Companies EXP(B)	High-Technology Companies EXP(B)
R&D workforce	0.121	1.128	0.640	3.128	0.993
Technology Development Cost	0.322	**1.380** *	7.260	1.866	1.075
A dedicated research institute	−0.240	0.787	3.444 **	1.201	1.291
Skill level	0.965	**2.625** *	1.013	0.999	1.007
Scale	0.188	1.207	1.038	1.217	0.886
Company type	0.514	**1.672** **	3.290 **	1.136	1.106
Industrial type	0.005	1.005	0.629	1.156	0.555
(Constant)	−3.200	0.041 ***	0.010	0.053	0.152
chi^2	51.20		32.95	11.30	11.12
Pseudo R^2	0.0355		0.1152	0.0143	0.0332
p-value	0.000 ***		0.000 ***	0.1260	0.1334

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5. Logistic analysis result on product competitiveness of technology development performance.

	B	Exp(B)	Low-Technology Companies EXP(B)	Medium-Technology Companies EXP(B)	High-Technology Companies EXP(B)
R&D workforce	0.165	**1.179** **	0.705	1.647	1.168
Technology Development Cost	0.160	1.174	1.333	2.860	0.930
A dedicated research institute	0.587	**1.799** ***	1.263	1.005	0.791
Skill level	0.453	1.572	1.008 *	1.012 ***	1.006
Scale	−0.040	0.961	1.066	1.229 **	1.198
Company type	0.042	1.043	0.943	1.273	1.263
Industrial type	0.010	**1.010** ***	1.920 *	1.701 **	1.712 *
(Constant)	−0.877	0.416 ***	0.505	0.357	0.642
chi^2	65.82		15.02	44.16	15.21
Pseudo R^2	0.0231		0.018	0.0289	0.032
p-value	0.000 ***		0.036 *	0.000 ***	0.033 *

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.3. Technology Commercialization Performance According to Technology Development Capability

While focusing on technology development performance as a subjective index, technical commercialization performance is composed of objective indicators as financial indicators. Among the items of technological development performance in the SME technical statistical survey, the sales by technology development and the exports by technology development, which are direct results through technology development activities, were considered as indicators.

The result of multiple regression analysis on the effect of technological development capability, which is a factor affecting the performance of technology commercialization, on the sales of technology business and medium technology development were verified. Adj-R^2 was 23.4% and it was significant. As shown in Table 6, as the size of the company increased by one unit, 3693 (million won) increased and in the type of industry, the manufacturing increased by 1425 (million won) In the case of technology development personnel, the number increased by 3044 (one million won). When the sales of technology development were targeted to the whole companies, the size of companies, types of industry, and technology development manpower were found to have an influence. In the enterprise scale, it affected the sales of technological development of three technology companies. However, other indicators of technology development competitiveness were different depending on the technology group, which affected the sales of technology development. In order to increase sales of low-technology companies, it is necessary to invest in more technology R&D expense.

The results of the multiple regression analysis on the export value of technology commercialization performance are shown in Table 7 and Adj-R2. As the size of the firm increased by one unit, it increased by 497 (million won), and the industrial type increased by 375 (million won) from the manufacturing industry other than the manufacturing industry. In the case of technology development workforce, it increased by 720 (one million won) by one unit. In the technical skill level, it increased by six million won as the number of units increased. In the enterprise type, the innovation company decreased by 249 (million won) compared to the general SME. The effect of technology development on the export value of technology development was shown by the size of enterprise, type of enterprise, type of industry, technology development manpower, and skill level, respectively. The level of technical skill was found to affect low-technology companies.

Table 6. Regression analysis result on sales of technology commercialization.

	B	Exp(B)	Low-Technology Companies EXP(B)	Medium-Technology Companies EXP(B)	High-Technology Companies EXP(B)
Scale	**3693.168** ***	21.93	1722.023 ***	3887.541 ***	4722.784 ***
Company type	−591.4564	−1.9	281.902	−741.047	−1376.17
Industrial type	**1425.612** **	3.33	803.387	1767.962 **	1123.988
R&D workforce	**3044.505** **	3.18	2244.824	3013.633 *	4520.107
Technology Development Cost	−77.69185	−0.77	−3700.39 *	−2253.97	−74.303
A dedicated research institute	427.8535	1.27	658.287	505.415	−742.213
Skill level	9.761781	1.34	10.255	13.68702	−10.061
(Constant)	−2387.191 **	−3.27	−1144.41	−2794.53	−557.826
R^2	0. 2365		0.2004	0.2327	0.2711
$Adj - R^2$	0.2341		0.1913	0.2283	0.2567
F	0.000 ***		0.000 ***	0.000 ***	0.000 ***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7. Regression analysis result on exports of technology commercialization.

	B	Exp(B)	Low Technology Companies EXP(B)	Medium Technology Companies EXP(B)	High Technology Companies EXP(B)
Scale	**497.514** ***	7.77	104.627	520.172 ***	769.922
Company type	**−249.292** *	−2.1	133.484	−423.104 *	−316.781
Industrial type	**375.39** *	2.31	279.667	340.51	527.862
R&D workforce	**720.664** *	1.98	518.665	666.222	1159.413
Technology Development Cost	−7.250	−0.19	−822.427	−164.348	−9.333
A dedicated research institute	195.645	1.52	75.833	243.163	217.293
Skill level	**6.036** *	2.18	4.568 *	8.041	0.960
(Constant)	−899.915 *	−3.24	−544.5	−968.239	−905.372
R^2	0.045		0.030	0.042	0.083
$Adj - R^2$	0.042		0.019	0.036	0.065
F	0.000 ***		0.000 ***	0.000 *	0.0001 ***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6. Conclusions

In order to analyze whether technological development performance depends on technological development capability, product competitiveness as whether the quality and performance of the product have improved through technology development activities was surveyed. Technology competitiveness was used as a measure of whether it had entered a new business field due to technology development activities.

As a result of the analysis, it was found that the technical development cost and technical skill level among the indicators constituting the technical development capability have an influence on the technical competitiveness of technical development performance. It was found that the more investment in technology development costs, the greater the probability of influencing technological competitiveness. Additionally, the technical skill level showed that the higher the technical skill level, the more likely it is to affect the competitiveness of technology by 2.6-fold. Therefore, Hypothesis 1-2 and Hypothesis 1-4 were verified. In this study, based on the existing research, if there was performance in a new business field entry, it was defined as having technical competitiveness. The higher the direct R&D cost and the higher the new technology development capability and commercialization capability, the higher the probability of entering the new business field. In the end, high technological competitiveness can be expected. Among the technological development performances, product competitiveness was influenced by technology development manpower and technology development research institute. It was proven that the probability of affecting product competitiveness increases by 1.7-fold if there is a research institute dedicated to technology development. Therefore, Hypotheses 1-5 and 1-7 were proven. This result seems to be due to the fact that if there are a lot of people in charge of technology development and a research institute dedicated to technology development, it is possible to respond quickly to product quality and performance improvement according to market demand. Many studies do not show consistent results because the relationship between technology development capability and technology development performance is multidimensional rather than one-dimensional. However, it is clear that technology development capability is not only a source of competitive advantage in product development, but also a key factor for continuous improved management performance.

In technology commercialization performance, technological development manpower influenced sales by technology development. In the case of exports by technology development, the level of technological development manpower and technical skill level had a significant effect on the export amount by technology development. If there are many technical development personnel, the research results related to technology development are likely to be derived. In addition, the greater the ability to develop new products and the greater the ability to commercialize technologies, the more likely it will directly affect the performance of technology development, further develop new products, and enter the market through the commercialization process. As a result, Hypotheses 2-1, 2-5 and 2-8 were proven. Zahra found that the higher number of professional technicians, the higher the commercialization of technological innovation [24]. In addition, the higher the level of technological development capability, the more favorable it was to create added value, such as sales.

In addition, we analyzed how the effect of technology development capability on technology development performance and technology commercialization performance varies according to each technology group. As a result of the analysis, it was found that the technological development capability and the technology development capability affecting the companies belonging to each technology group were different according to the technology development capability and the technology group. In the technology competitiveness of technology development performance, the presence of the institute dedicated to the development of technology among the technology development capability was found to affect the low-technology companies. In order to improve technological competitiveness, it is necessary to have a dedicated research institute for low-technology companies. In addition, in terms of product competitiveness, interesting results were found, unlike previous studies. The level of technology skill did not affect the overall level, but the analysis by dividing into technology

groups showed that it affects the product competitiveness of low- and medium-technology companies. The technical skill level can be explained by the ability of new product development and technology commercialization. It can be seen that the product competitiveness of low-tech companies and mid-tech companies is more sensitive to the level of technological skill than high-tech companies. According to the technology companies, the technology development capability affecting the turnover of technology commercialization performance was different. The lower the technology companies, the more research and development costs have to be invested. In addition, it was found that medium-technology companies should inject more technical development personnel. In the export portion, the level of technical skill was found to affect low-technology companies. In conclusion, it is necessary to actively improve technology development capability in order to grow low-tech companies.

In Korea's industrial economy, SMEs play an important role in employment and production, and SMEs account for a very large share. Technology development capability is very important for SMEs to enhance their competitiveness and performance, and furthermore, to create and strengthen a sustainable competitive advantage. However, despite many studies on the effect of technology development capability on technology development performance and technology commercialization, it does not reflect the situational and complex relationships and provides undesirable advice to improve the performance of SMEs.

The implications of this study are summarized as follows.

First, in order for SMEs to overcome many difficulties and grow into a midsize company, the most important goal of the company is to acquire capabilities that it lacks and to improve its capabilities and achieve high management performance. Therefore, it is significant that SMEs need to improve their skill development and technical commercialization performance by developing competencies.

Second, we analyzed the effect of technology development capacity on performance. Factors affecting performance were identified through previous research and analyzed and summarized. Previous studies have analyzed financial quantitative indicators only. In order to reflect these two perspectives, this study found a very meaningful effect in that technological development performance is composed of subjective and qualitative indicators and technical commercialization performance is composed of quantitative and objective indicators and these were examined from the multi-dimensional aspect.

Third, this study was based on a comparative analysis of technology companies. Most of the studies have been conducted on high-technology companies. Therefore, it is meaningful that this study was divided into high-technology companies, medium-technology companies, and low-technology companies. Because the situation and the level are different depending on the technology group, the competencies that are needed to improve performance are different. Therefore, this study is meaningful in that each of the technology companies that belong to each group are provided with suggestions on which part should be used more to improve the performance of the company.

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