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Research on the Effects of the Research and Development Capability of IT Firms on Business Management Performance

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ABSTRACT

To achieve sustainable growth in the industrial and market environment, companies need usable operational resources, the capability to utilize these resources, and a management strategy. Given their nature, IT firms must maintain and intensify their competitiveness through continuous research and development (R&D) to gain a differentiated competitive edge. In this study, the R&D capabilities of IT companies were classified into technology, marketing, and human resources capabilities, and analyzed to determine how they individually affect the firm's growth in reality. A total of 254 IT firms, established more than a decade ago, were selected for this study, tracing their business management performance from 2005 to 2014. It was found that technological capability had a positive effect on revenue growth and market capitalization, marketing capability had a positive effect on revenue and market capitalization, while human resources capability did not affect either. This research will have value as a basic reference for IT corporations, since it presents the results of a positive analysis on R&D capability and business management performance.

Keywords: IT corporations, R&D capability, technological capability, marketing capability, human resources capability, business management performance.

1. INTRODUCTION

Since the 1990s, many countries have carried out active research on the intellectual information age, referring to it as the most crucial hot topic of the 21st century. With the belief that the creation and utilization of knowledge, or a robust knowledge foundation, will enable them to become economic superpowers in the 21st century, many nations continue to accumulate knowledge.

For companies, intellectual property has already been identified as a crucial factor in the strategic decision-making process, and the ratio of intellectual property to total corporate value is increasing continuously.

Despite the desperate need for management strategies based on intellectual property, many companies, with limited investment capability and fundamental infrastructure, cannot react effectively due to practical restrictions in areas including technical resources, human resources, and finance. This applies even more so to IT firms that must maintain and strengthen a differentiated competitive edge through continuous research and development (R&D).

The purpose of this study is to categorize the R&D capabilities of Korean IT firms, established over a decade ago, into technology, marketing and human resources capabilities, and analyze how the use of these capabilities affects business management performance, and thereby propose ways to enhance management performance for IT firms when developing their growth strategies.

2. THEORETICAL STUDY ON MANAGEMENT PERFORMANCE AND R&D CAPABILITY OF IT FIRMS

2.1. Definition of IT Firms

The Information Technology (IT) industry refers to the manufacturing of computer hardware, software, and communication devices, and associated services. Paragraph 1 of Article 3 of the Framework Act on National Informatization defines the term ‘information’ in IT as all types of data or knowledge expressed in codes, letters, voice, sound, image, etc. after being processed by optical or electronic means for a specific purpose. The term ‘informatization’ refers to the production, distribution, or utilization of information to facilitate the creation and efficiency of activities in each sector of society. ‘Information and communications’ refers to the collection, processing, storage, retrieval, transmission, receipt, and utilization of information, and related equipment, technology, services, and activities, for the purpose of promoting informatization.

While nations have different classification systems for the IT industry, the Organization for Economic Cooperation and Development (OECD) classified it into two areas of information - the communications technology industry and the information contents industry, according to the International Standard Industrial Classification (ISIC). The United States Department of Commerce classifies the IT industry into four areas - hardware, communication devices, software and services, and communication services.

The World Information Technology and Services Alliance (WITSA) classifies the IT industry’s domestic market into six areas - IT hardware, software, IT services, internal IT, office equipment, and communications.

Table 16.1
IT Industry Classification System by WITSA

<i>Category</i>	<i>Contents</i>
IT Hardware	Server, PC, work station, data communication devices and parts, acquired by corporations, households, schools, and governments
Software	Software package, SI(System integration) and development service (excludes self-development)
IT Services	Consulting, installing, SM(System maintenance), IT education and support systems, etc. through subcontracted firms or agents

<i>Category</i>	<i>Contents</i>
Internal	All expenses including the corporation's information systems (IS) budget, internal software development, etc.
Office Equipment	All types of office equipment including calculators, photocopiers, POS(Point of sales), etc.
Communications	Cost of acquiring communications devices and services by corporations, households, schools, and governments

In this study, the IT industry is defined as the high-tech information communications technology industry categorized into information communications services, information communication devices, and software, as per Korea's classification of the same.

2.2. Definition of Business Management Performance

In evaluating the business management performance of companies, numerous researchers have used both subjective and objective measurements. Measuring management performance through statistical performance is the most widely used objective index, while the subjective index involves suggesting adequate levels of measurement criteria. Generally, researchers use both the objective and measurement indexes of finance performance to measure management performance.

Financial performance is the most universal measurement standard for management performance as it shows the extent of the company's achievement of its financial objectives. Financial performance indexes, generally obtained from financial statements, are easy to measure, and can be compared with other companies since they are objective and unified. Given these features, the indexes are most widely used for positive analysis.

Growth-related revenue and business profits are representative financial performance indexes. Revenue refers to sales income that is generated through general transactions involving the provision of goods and services, including products and commodities.

Park Kyung-joo (2007) stated that revenue is often used to evaluate the impact of corporate R&D on profitability, and is expressed as direct market feedback. It can be said that profitability is related to the corporation's internal capabilities. Additionally, he stated that profitability is an appropriate variable to measure a corporation's performance since it does not fluctuate due to mergers or acquisitions, and there is a strong statistical correlation between the financial performance and growth indexes.

According to Lee Jang-woo (2000), increased business management performance indicates corporate effectiveness, with sales growth rate used as the major index, while profitability is used to measure a corporation's effectiveness with return on sales and return on assets used as major indexes.

Yang Dong-woo and Park Yoon-ok (2011) argued that investment in intangible assets, including R&D, advertisement and promotion, and education and training, had a positive effect on business performance, although this may vary with company size.

Sales and net income are variables of corporate performance, which can be accessed through financial statements.

Given that sales are a good reflection of a company's competitiveness or profitability, it is widely used to identify a firm's growth. The company's state is considered good if its sales growth at the end of

the current quarter is 20% greater than that of the previous quarter, and is considered poor if the growth rate is below 10% (Bank of Korea, 2007).

2.3. R&D Capability

2.3.1. Technological Capability

Conventional research on strategic theory can be classified into the market-based view that highlights the importance of an organization's external environments when establishing strategies as shown in industrial organizational theory (Porter, 1979), and the resource-based view that stresses that a corporation gains its competitive edge from its differentiable resources and capabilities.

The resource-based view, which considers corporations based on their resources, has provided new explanatory theories for the success of certain firms since the 1980s (Wernerfelt, 1984; Barney, 1991; Nonaka & Takeuchi, 1995; Shim Ki-joon, 2011; Cho Dong-sung., 2014).

This view, first introduced by Wernerfelt (1984), defines resources as all things that can become both strengths and weaknesses for corporations, and referred to the unique aspects of a company's resources as the resource position barrier, arguing that internal resources can help a company maintain its competitive edge.

Williamson (1988) defined a company's intrinsic assets as assets that play a crucial role in creating profit, and explained that intrinsic assets are like strategic resources.

Barney (1991) combined similar concepts into resources, based on the premise that resources, abilities, and capabilities can be difficult to be distinguished in real life, and presented the VRIO Framework that classifies resource attributes into four categories - value, rareness, imitability, and organization. He also classified resources into financial, material, human, and organizational resources, and laid out the conditions in which these four categories are applicable as competitive edge factors.

Regarding the knowledge-based view, derived from the resource-based view, Grant (1996) argued that knowledge, among all other resources, is the basis for continuous creation of competitive advantage and wealth.

Technological development capability generally refers to product development and R&D, securing personnel with technical expertise, and other human resources and intellectual assets (Park Hae-wan, 2010; Kim Hyung-cheol, 2011; Ho Woong-ki, 2013).

Causality exists between a corporation's patent technology, R&D investment, and corporate performance, since patent information is a technical capability that links the corporation's R&D investment or innovative activities with corporate performance (Putnam, 1996).

Many studies regarding domestic firms state that intangible assets, including R&D expenses, number of patents and licenses owned, and development expenses, have a positive effect on corporate value (Kim Yong-in, Lee Dong-kyu, and Kim Hong-sik, 2003; Ahn Hong-bok and Kwon Ki-jeong, 2006).

According to a research on the relationship between intellectual property rights (IPR) and business management performance for venture companies by Park Hae-wan (2010), technological innovation and

possessing market information have a positive effect on IPR, and IPR, including patents, affected a firm's technological capability, which influenced business management performance.

2.3.2. Marketing Capability and Human Resources Capability

Vorhies (1998) divided marketing capability into product development, pricing, retailing, marketing communication, sales, market information management, marketing planning, and marketing execution capabilities. He defined marketing inputs as intangible assets that are accumulated in the process of repeated application of knowledge and technology to enable their transformation into marketing products.

Day (1999) argued that a firm's marketing capability could enhance management performance since a corporation's distinctive marketing capabilities are difficult to imitate and are thus a competitive advantage. Marketing capabilities include client and competitor information, marketing employee expertise, product and retail channel acquisition. Furthermore, he defined marketing capability as the comprehensive process of satisfying consumers' needs by identifying market needs and transforming knowledge, technology, and resources into products.

Chandler & Hanks (1994) suggests professional marketing knowledge as a business resource, arguing that marketing resources, including innovative marketing personnel, marketing expertise, and outstanding product marketing, have a positive effect on business performance. Management performance can be divided into two areas – growth-related management performance items measured using market share, cash flow, and sales growth rate, and size-related items measured using amount of sales, profit, and size of owner's capital.

While firm size may differ, Yang Dong-woo and Park Yun-ok (2011) argued that intangible asset-related investment, including R&D expenses, advertisement and promotion expenses, and education and training expenses, positively affect corporate performance. Additionally, they stated that advertisement and promotion was the most important spending item constituting a corporation's brand value, which is recognized as an important asset today, and refers to the cost spent on promotional activities targeting a group of non-specific audience to facilitate the sales of its products or goods.

Mocnik (2001) argued that companies with intrinsic assets would have a low debt ratio since intrinsic assets have low security value. Examples of intrinsic assets are R&D expenses and advertisement and promotion expenses. Previous studies indicate that there is a negative relation between intrinsic assets and debt ratio. Therefore, it can be argued that a corporation's intrinsic assets have a negative relation with capital structure.

Based on the knowledge management theory, Ahn Heung-bok and Kwon Ki-jeong (2006) stated that a corporation's R&D expenses and innovation index could increase its potential growth. Positive analysis results show that R&D expenses and innovation index both have a positive effect on corporate value. Moreover, they added that corporations that focus more on R&D have a greater value relevance.

Kim Ji-heon (2011) analyzed the comprehensive structural relation between marketing activities, brand assets, and brand performance, and concluded that advertisement expenses had a meaningful effect on brand assets, market share, and brand profit.

3. RESEARCH DESIGN FOR POSITIVE ANALYSIS

3.1. Developing the Research Model

Unlike previous research that consider the number of patents only as R&D achievements, this study considers patents as direct resources that can be utilized in areas ranging from technology and product quality guarantee, marketing and corporate competitiveness, and aims to look into the impact of technological development, marketing, and human resource capabilities on corporate performance. Based on this, the study also aims to review the effectiveness and level of usage of patent assets by firms by identifying whether IT firms have appropriately applied or registered patents as R&D achievements.

Furthermore, since organization and market domination are also related to securing a company's competitiveness, this study also aims to identify the achievements made using technological, marketing, and human resources capabilities. This is done by regarding marketing capabilities as sales facilitation expenses, and human resources capabilities as education and training expenses.

The study looked into how the process of improving business performance by securing and utilizing internal resources helps investors' in the decision-making process, or how it is used as information to support the decision-making process. To do this, the influence of market capitalization is studied.

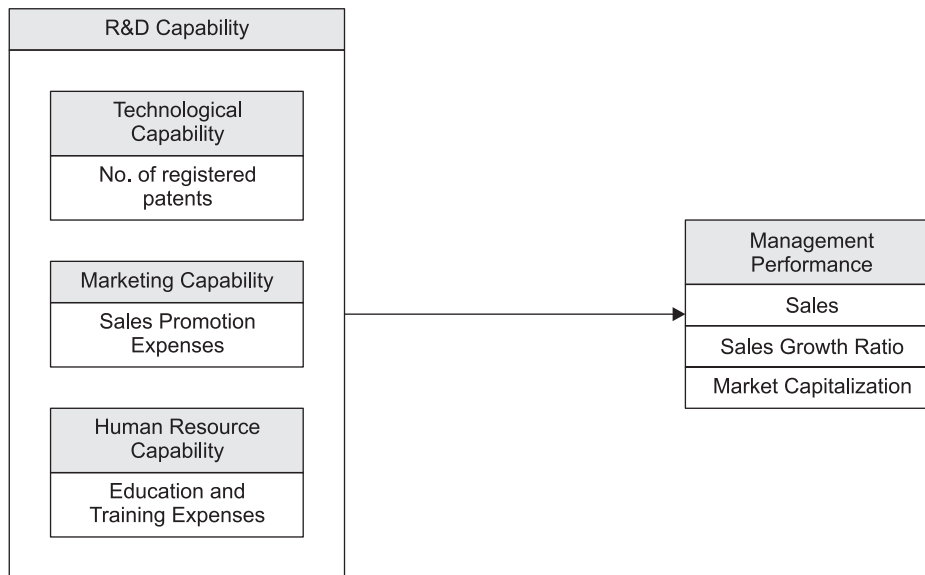


Figure 16.1: Research Model

The research model set technological, marketing, and human resources capabilities as independent variables, and set business performance as a subordinate variable to analyze the effect of a firm's technology, marketing, and human resources capabilities on business performance.

3.2. Developing the Research Hypotheses

Regarding technical capability, to identify how well companies legally protect their technical skills and their level of assured technology, this study investigated technical competitiveness in the domestic market through the registration of patents domestically.

Since patents can be used for promotion and aggressively reacting to the market from the time of registration, public information regarding patents since 2005, the start of the analysis period, was collected. The number of patent applications and registrations for this period was confirmed to calculate the number of registered patents. Since patents are not only used for a specific year, changes in business performance was analyzed based on the number of patents accumulated in the past decade. Sales promotion expenses, which can be used in a broader sense than advertisement and promotion expenses, were investigated and reflected as the marketing capability, while education and training expenses were investigated as the human resources capability based on publicly available financial material.

Based on previous research, the following hypotheses were set to analyze the effect of corporations' R&D capability on business performance.

Hypothesis 1: Technological capability of IT firms will have a positive (+) effect on management performance.

Hypothesis 1.1: The technological capability of IT firms will have a positive (+) effect on sales.

Hypothesis 1.2: The technological capability of IT firms will have a positive (+) effect on the sales growth ratio.

Hypothesis 1.3: The technological capability of IT firms will have a positive (+) effect on market capitalization.

Hypothesis 2: Marketing capability of IT firms will have a positive (+) effect on management performance.

Hypothesis 2.1: The marketing capability of IT firms will have a positive (+) effect on sales.

Hypothesis 2.2: The marketing capability of IT firms will have a positive (+) effect on the sales growth ratio.

Hypothesis 2.3: The marketing capability of IT firms will have a positive (+) effect on market capitalization.

Hypothesis 3: Human resources capability of IT firms will have a positive (+) effect on management performance.

Hypothesis 3.1: The human resources capability of IT firms will have a positive (+) effect on sales.

Hypothesis 3.2: The human resources capability of IT firms will have a positive (+) effect on the sales growth ratio.

Hypothesis 3.3: The human resources capability of IT firms will have a positive (+) effect on market capitalization.

3.3. Operational Definition of Variables

To advance this research, hypotheses must be proposed and the concepts of measurement items to be used in its positive analysis must be standardized. To this end, through the variables proposed in previous research, this study secured research logic and structure by seeking operational definitions that fit the research terms.

The operational definition of major variables and measurement items proposed in the research model to test the research hypotheses are explained below.

3.3.1. Definition and Measurement of Independent Variables

A. **Technological capability:** Analyzing patent information using statistical data on patent application and registration is generally helpful for future strategic decision-making. This is why the government also compares its technological level with other countries through patent trend analysis, when establishing the national technology road map and setting R&D areas to avoid duplicate investment. The purpose of this research was to help IT firms conduct effective patent management by identifying areas where their technological capability can affect business performance positively.

While it is desirable to use the number of patent applications to analyze patent assets, this number can be altered during the patent review administration process, through invalidation, abandonment, withdrawal, and decline, for instance. Hence, the number of patents registered is the most objective alternative. Therefore, the number of patent registered is used as variable in this study since it recognizes the firm’s value as an asset.

B. **Marketing capability and human resources capability:** Kim Yeon-yong (2004) measured marketing support capability using the ratio of sales to advertisement and promotion expenses. This ratio was used along with the ratio of sales to sales promotion expenses as independent variables to measure business performance, in terms of the sales growth ratio, gross profit on sales growth ratio, and operating profit growth ratio.

Kim Ji-heon (2011) measured brand profit using advertisement expenses, brand assets, and the market share ratio as indexes to examine the relation between marketing activities and brand performance.

To this end, sales promotion expenses and education and training expenses are selected as variables for marketing and human resources capability in this research, with reference to previous studies.

Table 16.2
Operational Definitions of Independent Variables

<i>Variable</i>		<i>Operational Definition</i>		<i>Evidence</i>
R&D Capability	Technological Capability	Number of registered patents	Log value of the total number of domestically registered patents during the past decade	Kil Sang-cheol et. al., (2008) Park Hae-wan (2010) Kim Ji-heon (2011)
	Marketing Capability	Sales promotion expenses	Average log value of the sum of sales promotion expenses per sale during the past decade	Kwon Oh-hyung (2011) Yang Dong-woo et. al., (2011) Ho Woong-ki (2013)
	Human Resources Capability	Education and training expenses	Average log value of the sum of education and training expenses per employee during the past decade	Shin Yong-jae (2011) Shim Ki-joon (2011) Kwak Jang-mi (2013)

3.3.2. Definition and Measurement of the Subordinate Variable

The indexes with the highest influence on business performance or those that have been confirmed by a number of advanced researches were selected and used as subordinate variables.

In the past decade, IT firms have grown experiencing various industrial environment and internal changes, and this research focuses on how the influence of economic fluctuations on corporations' growth is leading to overall weakening of profitability. To this end, sales, sales growth ratio, and market capitalization from the perspective of corporate value were selected as variables for analysis.

While stability and activity can influence business performance, they were excluded from this study to focus our research's scope and because their effect has been deemed insignificant by previous studies

Previous studies that analyzed the factors influencing business performance used education and training expenses and sales promotion expenses as variables related to investment (Ho Woong-ki, 2013), and used sales and the sales growth ratio to analyze the level of growth. Since the corporate value of KOSDAQ listed companies and those that went public in the securities market can be measured through public disclosure, corporate value was estimated based on market capitalization to investigate whether firms have maintained the most effective corporate value. Since financial statement analysis data, provided by NICE Information Service, are used to obtain market capitalization values, they can be considered validated.

Kim & Lee (2002) argued that the higher the technological capability, the more effective it is in creating sales and added value for the firm. Schoenecker & Swanson (2002) stated that using R&D expenditure, patents, the introduction of new products, and R&D intensity (R&D expenditure/sales) as indexes, technological capability had a positive effect on the sales growth ratio and management profits.

In his research, Yoo Tae-wook (2009) conducted positive analysis on the relationship between technological innovation activities and technological and economic performances, and found that technological innovation activities had a positive effect on technological performances like IPR (Intellectual property rights) and level of technology possessed. Technical innovation had a positive effect on the sales growth ratio, reflecting its influence on economic performance, and a negative impact on sales profitability.

Table 16.3
Operational Definitions of Dependent Variables

<i>Variable</i>	<i>Operational Definition</i>		<i>Evidence</i>
Business	Sales	Log value of sales in 2014 compared to that in 2005	Cheong Jin-ha (2004)
Management Performance	Sales Growth Ratio	Sales growth ratio in 2014 compared to that in 2005	Yoo Tae-wook (2009) Park Cheong-won (2013)
	Market Capitalization	Log value of market capitalization in 2014 compared to that in 2005	Seo Ran-joo et. al., (2011) Cho Hee-je (2014)

3.4. Designing Actual Investigation and Analysis Method

To accumulate the data necessary to conduct positive analysis, data on corporate financing and patents from 2005 to 2014 were collected from IT firms, excluding companies that shut down their businesses

and those that did not disclose their financial statements and number of employees. Additionally, observed values that exceeded the bottom and top 1% of the major variables were also excluded.

Based on the aforementioned procedures, a total of 254 IT companies were selected as final subjects for this study.

Table 16.4
Sources of Collected Material

<i>Category</i>	<i>Source</i>
General corporate information	Financial Supervisory Service Data Analysis, Retrieval and Transfer (DART), NICE Information Service KISLINE, companies' webpages
Financial data	NICE Information Service KISLINE
Patent data	WIPS Innovative Global Patent Information Provider (WIPS ON)

The accumulated data was analyzed using the SPSS 21.0 statistical program and the following steps were followed.

First, the patent information, financial statements, and corporate information were collected from target companies and were adjusted to the unit of million Korean Won while all the numbers and amounts were standardized using log value. This method was used to avoid distorted information analysis, given the wide discrepancy among numbers and amounts. Based on this data, frequency analysis was conducted.

Second, to analyze the relationship between R&D capability and management performance and to investigate the credibility of the variables of the technological, marketing, and human resources capabilities, reliability analysis was conducted after calculating the Cronbach Alpha value.

Third, correlation analysis was conducted to investigate the correlation among variables.

Fourth, multiple regression analysis was conducted to identify the influence of technological, marketing, and human resources capabilities on business management performance.

4. POSITIVE ANALYSIS

4.1. Basic Statistics Analysis of Research Targets

The classification of companies, according to their average sales for the period 2005-2014, is presented in Table 16.5.

Table 16.5
Management Performance of Sample Corporations

<i>Feature</i>	<i>Scope</i>	<i>Frequency</i>	<i>Ratio</i>
Sales	Under 10 bil KRW	11	4.34
	10 ~ 30 bil KRW	48	18.89
	30 ~ 50 bil KRW	76	29.92
	50 ~ 100 bil KRW	75	29.53
	Over 100 bil KRW	44	17.32

The average number of registered patents was 35.38, and the sales promotion and education and training expenses, per 100 million KRW of sales, were 4.12 million and 1.49 million KRW, respectively.

Table 16.6
R&D Capability of Sample Corporations

<i>Category</i>	<i>Analysis N</i>	<i>Minimum Value</i>	<i>Maximum Value</i>	<i>Average</i>	<i>Standard Deviation</i>
No. of registered patents	187	1	453.00	35.38	61.06
Sales promotion expense per 100 mil KRW sales	208	.00	32.23	412.35	529.36
Education and training expense per 100 mil KRW sales	208	.00	1247.09	149.63	274.15

4.2. Verification of the Research Hypotheses

4.2.1. Verification of Variable Reliability and Validity

The reliability analysis results showed that the Cronbach Alpha value was 0.612, and no items used as indexes were found to hinder reliability. The data used in this research were values measured for a single concept, and since they were panel data collected and processed by public institutions, their reliability and validity are guaranteed.

Moreover, the study studied the level of linearity among variables using correlation analysis to review the construct concept and discriminant validity of the measuring tools.

If a variable is found to have an apparent linear relationship with another one due to high correlation among variables, the correlation coefficient will be either 1 or -1. Generally, when the absolute value of the correlation coefficient is between 0.4 (included) and 0.7, there is a relatively high correlation, and when it is between 0.2 (included) and 0.4, it is said to have a low correlation, while there is no correlation when it is below 0.2 (Song Ji-joon, 2009).

Table 16.7
Correlation Analysis among Variables

<i>Category</i>	<i>No. of registered patents</i>	<i>Sales promotion expenses</i>	<i>Education and training expenses</i>	<i>Sales</i>	<i>Sales growth ratio</i>	<i>Market capitalization</i>
Patent registration	1	.089	.078	.130	.186**	.252**
Sales promotion expenses	.089	1	.662**	.375**	-.019	.404**
Education and training expenses	.078	.662**	1	.212	-.090	.277**
Sales	.130	.375**	.212	1	.088	.363**
Sales growth ratio	.186**	-.019	-.090	.088	1	.058
Market Capitalization	.252**	.404**	.277**	.363**	.058	1

**Correlation is significant in the level of 0.01.

*Correlation is significant in the level of 0.05.

When the correlation coefficient is 0.8 or more in regression analysis, it can be said that multicollinearity exists as interactions takes place; however, in this research, the maximum correlation coefficient stood at 0.662, thus proving no multicollinearity was found.

When the correlation coefficients among major variables were studied, the number of registered patents had a positive correlation with the sales growth ratio and market capitalization, while a positive correlation

was witnessed between sales promotion expenses and sales as well as market capitalization. Education and training expenses had a positive relation with sales and market capitalization.

4.2.. Relation Hypothesis between R&D Capability and Management Performance

Table 16.8 shows the results of the multiple regression analysis conducted to verify the effects of the number of registered patents indicating the technological capability, sales promotion expenses indicating the marketing capability, and education and training expenses indicating the human resources capability on sales indicating management performance.

The regression equation has a 73.6% explanatory power with $R^2 = .736$, and the regression model is statistically significant with the F value being 103.79 and the p value being 0.01 or below.

Furthermore, the regression model can be said to be appropriate since there is no correlation among residuals with a Durbin-Watson verification value of 1.930, which is close to 2 and not to 0 or 4. The tolerance limit value is .931 for the number of registered patents, .582 for sales promotion expenses, and .789 for education and training expense, all being over .01, while the VIF values are all under 10, and thus no witnessed issues with multicollinearity.

Table 16.8
Relational Verification between R&D Capability and Sales

Category	Non-standard coefficient		Standard coefficient	t	Significant level	Tolerance limit	F
	B	Standard error	Beta				
No. of registered patents	.020	.022	.045	1.034	.314	.931	103.79
Sales promotion expenses	.071	.038	.087	1.701	.080*	.582	
Education and training expenses	-.010	.021	-.044	-.608	.508	.789	

Dependent variable : Sales

$R = .831, R^2 = .736, \text{modified } R^2 = .744, p = .000^{***}, \text{Durbin-Watson} = 1.930$

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

While technological capability had no effect on sales with the above conditions, marketing capability had a significant effect on sales.

It was also confirmed that marketing capability has a direct effect on IT firms' growth, and that sales promotion expenses has a positive effect on sales growth.

Therefore, the pre-set hypothesis 1-1 that technological capability will have a positive effect on sales was rejected, while hypothesis 2-1 that marketing capability will have a positive effect on sales was adopted, and hypothesis 3-1 that human resources capability will have a positive effect on sales was rejected.

Table 16.9 shows the results of the multi-regression analysis to verify the effects of R&D capability on the sales growth ratio as an indicator of management performances.

With the modified $R^2 = .089$ for the regression equation, it has an explanatory power of 8.9%, and the regression model was statistically significant with the F value being 5.112 and the p value being under 0.01.

Additionally, the regression model can be said to be appropriate with a Durbin-Watson verification value of 1.802. The tolerance limit value is .930 for the number of registered patents, .587 for sales promotion

expenses, and .823 for education and training expenses, all being over 0.1, while the VIF values are all under 10, and thus no witnessed issues with multicollinearity.

Table 16.9
Relational Verification between R&D Capability and Sales Growth Ratio

Category	Non-standard coefficient		Standard coefficient	t	Significant level	Tolerance limit	F
	B	Standard error	Beta				
No. of registered patents	.018	.007	.120	2.392	.013**	.930	5.112
Sales promotion expenses	.009	.019	.055	.598	.533	.587	
Education and training expenses	.002	.006	.010	.100	.823	.702	

Dependent variable : Sales growth ratio

R = .355, R² = .112, modified R² = .089, p = .001***, Durbin-Watson = 1.802

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

Based on the aforementioned analysis, technological capability had a positive effect on the sales growth ratio.

Therefore, the pre-set hypothesis 1-2 that technological capability will have a positive effect on the sales growth ratio was adopted, while hypotheses 2-2 and 3-2 that marketing and human resources capabilities will have a positive effect on the sales growth ratio were rejected.

Table 16.10 shows the results of the multi-regression analysis to verify the effects of R&D capability on market capitalization.

Table 16.10
Relational Verification between R&D Capability and Market Capitalization

Category	Non-standard coefficient		Standard coefficient	t	Significant level	Tolerance limit	F
	B	Standard error	Beta				
No. of registered patents	.070	.055	.126	1.801	.052**	.932	21.705
Sales promotion expenses	.268	.089	.315	4.087	.000***	.506	
Education and training expenses	-.039	.086	-.124	-1.133	.333	.719	

Dependent variable : Market Capitalization

R = .620, R² = .492, modified R² = .413, p = .001***, Durbin-Watson = 2.224

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

With the modified R² = .492 for the regression equation, it has an explanatory power of 49.2%, and the regression model was statistically significant with the F value being 21.705 and the p value being under 0.01. Moreover, the regression model can be said to be appropriate by with a Durbin-Watson verification value of 2.224. The tolerance limit value is .920 for technological capability, .506 for marketing capability, and .719 for human resources capability, all being over 0.1, while the VIF values are all under 10, and thus no witnessed issues with multicollinearity.

The analysis results shows that technological and marketing capabilities had a positive effect on market capitalization, while human resources capability did not.

Therefore, the pre-set hypotheses 1-3 and 2-3 that technological and marketing capabilities will have a significant effect on market capitalization were adopted, while hypothesis 3-3 that human resources capability will have a positive effect on market capitalization was rejected.

4.3. Summary of Hypotheses Verification Results

The subsequent review of the research model using multiple regression analysis shows that an increase in the number of registered patents, which is a technological capability, had a positive effect on the sales growth ratio and market capitalization, while marketing capability had a positive effect on sales and market capitalization. However, human resources capability did not have the expected influence, and thus all related hypotheses were rejected.

5. CONCLUSION

5.1. Summary of Research Results and Implications

Among R&D capabilities, technological capability had a positive effect on the sales growth ratio and market capitalization of IT firms, and marketing capability had a positive effect on sales and market capitalization, while human resources capability did not affect either.

Table 16.11
Summary of Research Results

<i>Category</i>	<i>Hypothesis</i>	<i>Adoption/Rejection</i>
[Hypothesis 1]	The technological capability of IT firms will have a positive effect on management performance.	Partially adopted
1-1	The technological capability of IT firms will have a positive effect on sales.	Rejected
1-2	The technological capability of IT firms will have a positive effect on the sales growth ratio.	Adopted
1-3	The technological capability of IT firms will have a positive effect on market capitalization.	Adopted
[Hypothesis 2]	The marketing capability of IT firms will have a positive effect on management performance.	Partially adopted
2-1	The marketing capability of IT firms will have a positive effect on sales.	Adopted
2-2	The marketing capability of IT firms will have a positive effect on the sales growth ratio.	Rejected
2-3	The marketing capability of IT firms will have a positive effect on market capitalization.	Adopted
[Hypothesis 3]	The human resources capability of IT firms will have a positive effect on management performance.	Rejected
3-1	The human resources capability of IT firms will have a positive effect on sales.	Rejected
3-2	The human resources capability of IT firms will have a positive effect on the sales growth ratio.	Rejected
3-3	The human resources capability of IT firms will have a positive effect on market capitalization.	Rejected

This study is meaningful in that it looked at how IT firms have grown through R&D from 2005 to 2014, and has value as material for the creation of a desirable growth road map, as it indicates how companies have optimized the use of their internal resources and in turn, improved their management performance.

It is clear that technology-based IT firms will be the new drivers of Korea's economy. However, for these firms to compete in the market, they need to develop a growth road map through effective management and use of internal resources, along with continuous R&D. For this, they need to be equipped with the competitiveness required to react flexibly to changing circumstances.

5.2. Limitations of the Research and Future Research Directions

Since this research is exploratory in nature, investigating the R&D capability and management performance of IT firms, the limitations of this research are explained below.

First, while the effects of the technological, marketing, and human resources capabilities on management performance have been tracked and analyzed, a multi-faceted review was not possible as the research failed to set sufficient variables.

Second, given that education and training expenses were used as proxies for the human resources capability, most of them showed no influence. Therefore, future research should study indexes that can measure organizational capability, thereby investigating the mutual relevance, relation, and supplementary roles between human talent nurturing, strengthening organizational capability, and management performance.

Finally, since the research was conducted based on disclosed financial data and patent information, its reliability is limited in that it did not fully reflect the reality of recent trends. To overcome these limitations, non-disclosed patents, or the present state of R&D should be investigated and reflected in future research to be more effective in predicting recent states and trends.

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