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The Roles and Characteristics of R&D Investment in the IT Firms: IT Hardware Firms vs. IT Software Firms

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Investment in research and development (R&D) is critical in the information technology (IT) firms, where newer and better technology is a quintessential goal that directly affects innovation and competitive advantage. This study investigates how R&D investment influences firm performance and value, and how the effect of R&D investment differs between IT hardware and software firms. We also analyze the relationship between firm age and R&D investment in order to identify learning effects on continuous R&D investment. The empirical investigation in this study, based on longitudinal archival data from 2001 to 2010, found a significant effect of R&D investment on firm performance in IT firms. Further, this study demonstrates causal relationship between firm age, and verifies that learning effects are present in R&D investment. Moreover, the results are found to differ between IT hardware and IT software firms.

Keywords : R&D Investment, Tobin's Q, Firm Performance, IT Firms, Hardware Firm, Software Firm

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Ⅰ. Introduction

Given fast-changing management environments and the growing importance of securing competitiveness in the global arena, innovation has become the key to sustainable growth and development for IT firms. Innovation in R&D is especially critical as newer and better technology is a primary determinant affecting current and future competitive advantage [Bardhan *et al.*, 2013]. For example, IBM and CISCO Systems, two representative IT hardware companies, invested $6.3 billion and $5.8 billion in R&D in 2011, respectively. Furthermore, Microsoft spent $9 billion, nearly 13% of its revenue, on R&D [Business Insider, 2012]. Despite the sizable growth of R&D investment, a degree of skepticism concerning the value of R&D investment has recently emerged [Forbes, 2012]. Under this situation, a research question can be raised: *Can R&D investment effect firm performance in the IT industry?*

In fact, some prior studies have examined the relationship between R&D investments and firm performance in the IT industries [e.g. Tsai and Wang, 2004]. However, although IT hardware and software industries have different characteristics, previous studies did not examine how the effect of R&D investment differs between these two different industry environments.

On the other hand, as the research methodological aspect, prior studies have primarily focused on R&D's effect on profit, productivity, revenue dimensions. However, recent studies examined the effects on stock earnings ratio or Tobin's Q [Mithas *et al.*, 2012; Kohli *et al.*, 2012]. This is because Tobin's Q can be used to predict current corporate value as a function of predicted future performance, based on projected R&D investment. That is, Tobin's Q can be utilized as a useful indicator to gauge R&D activities performance and profit measurement [Bardhan *et al.*, 2013].

Therefore, this study investigates the effect of R&D investment on firm performance and value, based on ROA and Tobin's Q, and specifically addresses whether, the effect of R&D differs between IT hardware and software environments.

The study is then extended to determine if there is a possible *learning effect* on a firm's R&D investment, based on previous R&D levels. IT companies will generally continue to perform R&D activities in order to improve their performance and seek growth opportunities. If learning effects from R&D activities exist, it is predicted that maturing firms will likely spend less on R&D to achieve the same level of research performance. This is because continuing experience leads to the accumulation of knowledge, which can improve firm productivity [Camisón and Forés, 2010]. This phenomenon may be observed not only in productivity, but also in R&D, and it is thus relevant to a firm's knowledge assimilation capability [Cohen and Levinthal, 1989; 1990; Fabrizio, 2009; Camisón and Forés, 2010]. As firms age, there is a possibility that they will produce the same R&D outcomes with diminishing R&D investment. This phenomenon, it is hypothesized, will show different results for IT hardware and software firms.

To perform this study, we analyzed longitudinal archival data on IT firms from a large sample by applying the ROA and Tobin's Q ratio as models. In investigating R&D investments and firm performance, we made use of various measurement techniques not used in previous studies; the study was then further extended by parsing the different IT companies into hardware and software firms.

Ⅱ. Literature Reviews and Hypothses Development

The relationship between R&D investment and firm performance has long been discussed in the fields of information systems and economics [Dedrick *et al.*, 2003; Melville *et al.*, 2004]. There is ample evidence that R&D investment can have a positive effect on firm performance and value. In an early study, Ravenscraft and Scherer [1982] found that the future profits of a firm were positively associated with R&D investments. Bublitz and Ettredge [1989] examined the effects of advertising and R&D investments on stock values based on a sample of 328 firms from 10 years. Advertising expenditures had a negative effect on stock values, while R&D investment had a positive effect. The analysis indicated that advertising has only short-term effects, whereas R&D investment has effects that persist over a longer period of of time.[1)]

To better measure the effect of R&D investment on firm performance, recent studies have shifted attention to financial market measures such as Tobin's Q, a forward-looking measure of a firm's value that takes into consideration lag effects [Kohli *et al.*, 2012]; by measuring the value of a firm based on its future earnings, relative to its current book value, Tobin's Q can serve as a better indicator of future growth potential [Bardhan *et al.*, 2013].

Kohli *et al.*, [2012] tested the effect of IT investment on a firm's value combined with a measure of financial performance. The findings showed that the effect of IT investment on firm value is clearer and more significant than its effect on accounting performance measures, such as the ROA. Furthermore, Bardhan *et al.* [2013] empirically examined the interaction effect of IT and R&D investment on Tobin's Q and found that it was strongly positive.

Based on the extant literature, we hypothesize that R&D investment has a positive association with a firm's performance. Specifically, similar to Kohli *et al.* [2012], we use ROA and Tobin's Q in order to investigate the effect of R&D investment.

Hypothesis 1: R&D investments in IT firms have a positive effect on firm's performance.

Hypothesis 1-1: R&D investments in IT firms have a positive effect on firm's value (Tobin's Q).

Hypothesis 1-2: R&D investments in IT firms have a positive effect on firm's earnings (ROA).

Despite the existence of two industries (IT hardware and IT software) with different characteristics, many studies were conducted to analyze the entire IT industry [Kohli *et al.*, 2012, Bardhan *et al.*, 2013]; while some studies were limited to the software industry, a downstream component of the IT industry [West and Gallagher, 2006, Lavie, 2007].

1) According to Cho and Chung [2001], the effect of R&D expense on profit is maintained for 2~4 years in Korean companies (5~9 years for U.S. companies). Here, the period of 4 years is computed by including the corresponding year (t). This means that the expenses will affect profit for the next 3 years (t+1, t+2 and t+3). In addition, electric/electronic industries highly related to this study were found to show the effect of R&D expense on profit of t+2 and t+3.

Fundamental differences between the two industries, for example, can be found in the importance of human capital. In software in the industry, human capital is extremely important compared to the hardware industry [Arora and Athreye, 2002]; while plant and equipment resources are more important for the hardware industry [Egeraat and Jacobson, 2004]. Due to such differences, the software industry shows greater flexibility and a shorter life cycle of products, in comparison to the hardware industry. However, there are no studies that have compared the differences between the IT hardware and software industries.

These effects are expected to differ between IT hardware and software firms. In the case of the IT software firm, the knowledge- and technology-intensive nature of the firm leads to very quick development; thus, the effect of R&D investment on firm performance is expected to be greater in the software rather than in the hardware firm [Boden and Miles, 2000; Aramand, 2008]. This leads to the following hypothesis.

Hypothesis 2: R&D investment effects on a firm's performance are greater in IT software firms compared to hardware counterparts.

Hypothesis 2-1: R&D investment effects on a firm's value are greater in IT software firms compared to hardware counterparts.

Hypothesis 2-2: R&D investment effects on a firm's earnings are greater in IT software firms compared to hardware counterparts.

As companies gain more experience, they accumulate knowledge, leading to increased productivity [Balasubramanian and Lee, 2008]. This notion also applies to R&D, with more experience leading to enhanced knowledge assimilation capability [Cohen and Levinthal, 1989; 1990]. Thus, maturing firms will likely spend less on R&D to achieve the same level of research performance.

Little is known about the relationship between a firm's years in business and R&D investment. Recent studies have attempted to investigate the issue empirically. Huergo and Jaumandreu [2004], for example, used panel data to find that new firms spend more on innovation-related activities. Hur [2011] studied the knowledge-based economy and reported that firm age as a controlled variable showed a negative effect on R&D investment.

Hypothesis 3: In IT industry, firm age has a negative effect on R&D investment.

In addition, the relationship between firm age and R&D investment may differ between IT hardware and software firms. In the IT hardware firm, technological development is concentrated in a firm's early years, and the accumulation of knowledge and intelligence over time can lead to a decrease in R&D investment [Boden and Miles, 2000]. On the other hand, technological development is much quicker in the software firm, and the fact that competitors can easily replicate or come up with superior products necessitates continuous investment in R&D [Aramand, 2008]. Thus, the negative relationship between firm age and R&D investment is expected to be greater in the IT hardware firm, leading to the following hypothesis.

Hypothesis 4: The negative relationship between IT firm age and R&D investment is greater in the hardware compared to the software firm.

Ⅲ. Research Design

3.1 Research Models

The following model, Model 1, has been formulated in order to test that R&D investment effects firm value (H 1-1).

$$TQ_{t+1}\,(\text{or } TQ_{t+2}\text{or } TQ_{t+3}) = \beta_0+\beta_1 RD_t+\beta_2 SIZE_t+\beta_3 AGE_t + \beta_4 LEV_t+\beta_5 GRW_t+\sum YEAR+\epsilon \quad (1)$$

$$TQ_{t+1}\,(\text{or } TQ_{t+2}\text{or } TQ_{t+3}) = \beta_0+\beta_1 RD_t+\beta_2 DD+\beta_3 RD\times DD + \beta_4 SIZE_t+\beta_5 AGE+\beta_6 LEV_t + \beta_7 GRW_t+\sum YEAR+\epsilon \quad (2)$$

<Where>

- TQ_{t+1} = (total asset+market value of equity-book value of equity)/total assets at time t+1
- TQ_{t+2} = (total asset+market value of equity-book value of equity)/total assets at time t+2
- TQ_{t+3} = (total asset+market value of equity-book value of equity)/total assets at time t+3
- RD_t = R&D investment/beginning total assets at time t
- DD_t = If a firm belongs to the IT software firm then 1 or belongs to the IT hardware firm then 0
- $SIZE_t$ = natural logarithm of total assets at time t
- AGE_t = natural logarithm of firm's age at time t
- LEV_t = Total debt/total assets at time t
- GRW_t = (sales at time t-sales at time t-1)/beginning total assets at time t
- $YEAR$ = Year indicators

The dependent variable used in this model, Tobin's Q, is measured by adapting the method used by Chung and Pruitt [1994]. It needs to be noted that R&D activity itself does not increase the profits and value of a firm; rather, successful development activities leading to the creation of commodities are what generate increases in value and profits.

When measuring the dependent and independent variables over the same period of time, a possible endogeneity problem arises, where there is difficulty establishing a causal relationship in the time-series relationship. To solve the endogeneity problem, a model with the dependent variable at t+1 versus the independent variable at t was used. In addition, because the effect of R&D can appear after the next period, the dependent variable also includes t+2 and t+3.[2)]

Among the independent variables, the test variable is R&D investments broken down into underlying assets (beginning total assets); if an increase in R&D investment has an effect on firm value, the variable will have a positive value.

2) The reason is that we regarded the time difference based on a prior study [Cho and Chung, 2001]. According to Cho and Chung [2001], the effect of R&D expense on profit is maintained for 2~4 years in Korean companies [5~9 years for U.S. companies]. Here, the period of 4 years is computed by including the corresponding year (t). Exclusion of this means that the expense will affect profit for the next 3 years (t+1, t+2 and t+3). In addition, electric/electronic industries highly related to this study were found to show the effect of R&D expense on profit of t+2 and t+3. In summary, our attempt to examine t+1~t+3 of time difference in dependent variable presents an advantage of resolving the endogeneity issue of independent and dependent variables, simultaneously considering the fact that R&D investment affects future performance with time difference.

The controlled variables are firm SIZE, AGE (firm age)[3], LEV (debt to asset), and GRW (growth rate of sales). SIZE s is a proxy for firm size, represented by the natural log of the beginning total assets. Likewise, AGE is the natural log of the firm age; according to Khanna and Palepu [2000], firm age is negatively correlated with firm value. Leverage (LEV) is a value obtained by dividing total debt by total assets. Modigliani and Miller [1963] revealed that when using debt capital, the effect of tax savings leads to a decrease in the weighted average cost of capital, potentially increasing the firm value. Ross [1977] asserted that business holders may choose to have a high debt percentage in order to signal positive trends in the firm, causing a positive correlation between the percentage of debt and firm value. As a proxy that controls growth, the growth rate of net income for the current year compared to the previous year has been used and is represented by the variable GRW.

3) Variables other than size and age were controlled of heteroscedasticity through scale. For instance, R&D expense was scaled by asset at the beginning of the year, and liabilities were also scaled by asset at the beginning of the year. However, size and age need adjustment because scaling of these variables is inappropriate. In addition, distribution of size and age is generally clustered in the section with small amount of expense. In other words, the distribution is skewed to the right side. We took natural log of size and age as done so in previous studies in order to resolve this skewness. For reference, studies that took natural log of size as in this study include Francis *et al*. [2004], Defranco *et al*. [2011], Kwon *et al*. [2009] and others. Previous studies that took natural log of time such as age include Francis *et al*. [2004, variable for operating cycle], Defranco *et al*. [2011, variable for days], Kwon *et al*. [2009, variable for horizon], and so forth.

Model 2 involves the further classification of the IT firms into hardware and software firms and their possible effect on the results of Model 1. The dependent variable is Tobin's Q of Hypothesis 2-1. If the hypothesis of this study is correct, the value of DD×RD will be positive.

Next, Model 3 has been established to measure the effect of R&D investments on firm accounting performance (earnings, ROA) in the IT firms (H 1-2).

$$ROA_{t+1}\,(\text{or } ROA_{t+2} \text{ or } ROA_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 SIZE_t + \beta_3 LEV_t + \beta_4 MB_t + \sum YEAR + \epsilon \tag{3}$$

$$ROA_{t+1}\,(\text{or } ROA_{t+2} \text{ or } ROA_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 DD_t + \beta_3 RD_t \times DD_t + \beta_4 SIZE_t + \beta_5 LEV_t + \beta_6 MB_t + \sum YEAR + \epsilon \tag{4}$$

<Where>

ROA_{t+1} = net income/beginning total assets at time t+1
ROA_{t+2} = net income/beginning total assets at time t+2
ROA_{t+3} = net income/beginning total assets at time t+3
RD_t = R&D investment/beginning total assets at time t
DD_t = If a firm belongs to the IT software firm then 1 or belongs to the IT hardware firm then 0
$SIZE_t$ = natural logarithm of total assets at time t
LEV_t = Total debt/total assets at time t
MB_t = market value of equity/book value of equity at time t
$YEAR$ = Year indicators

The dependent variable ROA represents the firm's net profit during period. As in Model 1, the dependent variable is t+1, 2, and 3. The test variable is R&D investment (RD) divided by underlying assets; if investing in R&D has a positive effect on firm's earnings, the variable will have a positive value.

The variables representing basic characteristics of a firm, which are firm size (size), leverage ratio (LEV) and growth opportunity (MB), were included in the model equation as control variables [Park *et al*., 2011 and Core *et al*., 1999]. According to the previous studies, size is a measure that represents various omitted variables. LEV is one of the typical variables that show company risks such as financial risk and bankruptcy risk [Park *et al*., 2011]. A firm with a high LEV ratio bears heavy interest costs, which are likely to have adverse effects on the net profit during the term. LEV is, thus, expected to have a negative (-) relation with accounting income. And a high MB ratio means that a firm has a higher chance to succeed in making profit, so MB is considered to have a positive (+) relation with accounting income.

Model 4 involves the further classification of the IT firms into hardware and software firms and their possible effect on the results of Model 3. The dependent variable is the ROA of Hypothesis 2-2. If the hypothesis of this study is correct, the value of DD×RD will be positive.

Model 5 has been formulated to measure the effect of firm age on R&D investments in the IT firms (H3). R&D investment (RD) is the dependent variable, and the test variable is firm age (AGE). If R&D investments decrease with increasing firm age, the variable will show a negative coefficient, but it will not have a significant value if there is no effect. The controlled variables are firm SIZE and % debt (LEV), which are known by economists to be related to R&D investment. In addition, firm performance (ROA) and MB have been included. Firm performance substitutes for a firm's financial limitation [Bougheas *et al*., 2001].

Model 6 serves to test Hypothesis 4; if the hypothesis of the current study is correct, the value of AGE×DD will be positive.

$$RD_t = \beta_0 + \beta_1 AGE_t + \beta_2 SIZE_t + \beta_3 LEV_t + \beta_4 ROA_t + \beta_5 MB_t + \sum YEAR + \epsilon \quad (5)$$

$$RD_t = \beta_0 + \beta_1 AGE_t + \beta_2 DD_t + \beta_3 LEV_t \times DD_t + \beta_3 SIZE_t + \beta_4 LEV_t + \beta_5 ROA_t + \beta_6 MB_t + \sum YEAR + \epsilon \quad (6)$$

<Where>

RD_t = R&D investment/beginning total assets at time t

AGE_t = natural logarithm of firm's age at time t

DD_t = If a firm belongs to the IT software firm then 1 or belongs to the IT hardware firm then 0

$SIZE_t$ = natural logarithm of total assets at time t

LEV_t = Total debt/total assets at time t

ROA_t = net income/beginning total assets at time t

MB_t = market value of equity/book value of equity at time t

$YEAR$ = Year indicators

3.2 Data

We use longitudinal archival data from 2,390 IT companies in Korea, specifically R&D expenditure data from 2001 to 2010. Korea is one of the world's highest technology countries, possessing various advanced IT firms such as Samsung and LG. IT has taken a prime role in Korea's economy, contributing to more than 5.5% of total employment and 11% of GDP. Moreover, IT companies contribute more than 22% of the overall economic growth in Korea

[NITPA, 2011].

In detail, we use data from companies listed on the Korean Stock Exchange's (KSE) KOSDAQ market during all of the years from 2001 to 2010, while meeting the following requirements: categorized under the IT companies during the above period, December 31 fiscal year end, not a delisted firm; and not a firm experiencing deficits.

The first requirement limits the targets to companies categorized by the KSE as belonging to IT hardware and software categories,[4] the second requirement excludes non-December 31 fiscal year end companies in order to control for the effect of stock price depending on the fiscal month. Requirements 3 and 4 are set to eliminate companies that may potentially make the results less reliable. Based on these four requirements, 2,390 firm-year samples were selected, with observation exceeding ±1% Winsorized as outliers. The financial and stock data for this study were obtained from Data Guide Pro provided by FnGuide.

The variable R&D investment is generally broken down into various accounting subjects (research, development, manufacturing cost, etc.) in financial statements, but in Korea, R&D investments are shown as an annotated item on the financial statements, making the data more accurately obtainable.

4) Korea Stock Exchange classifies IT businesses of companies listed on KOSDAQ into ① IT S/W & SVC (IT software hereafter) industry and ② IT H/W (IT hardware hereafter), and sub-categories of IT software include the internet, digital contents, software, and computer service industry. Sub-categories of IT hardware include communication equipment, information device, semiconductor, and IT parts industry.

Ⅳ. Empirical Results

4.1 Summary Statistics

<Table 1> summarizes the technological statistics of the 2,390 companies. For the dependent variables, Tobin's Q (TQ) is generally higher in the software firm, whereas firm performance (ROA) is higher in the hardware firm. This suggests that firms in the software firm tend to perform higher than those in the hardware firm with the same business performance. The variable of interest, R&D investments (RD), has a mean of 0.052 and median of 0.037, indicating that, on average, 5.2% of all assets are R&D investments, equivalent to about $2.5m invested for R&D annually. The average value of RD for the software firm is 0.052, equivalent to that of the hardware firm. For the controlled variables, SIZE, AGE, % debt (LEV), and % profit increase (GRW) showed higher values in the hardware firm. In contrast, market vs. book value (MB) showed higher values in the software firm.

<Figure 1> shows yearly distribution of key variables. For R&D investment, there is an increase showing both in hardware and software firms, and though not showing a specific trend, Tobin Q decreased significantly in 2008. The reason is because Korea was not fully out of the aftermath of financial crisis in the late 1990s. Hardware firm does not show a well-defined trend with respect to ROA, but for software firm, there is a loss in the early of 2000s, and gain starting in the late of 2000s. Firm's age (before natural logging) obviously shows increase over the year, and it is shown that hardware firms show greater firm age than software firm age, in general.

<Table 1> Descriptive Statistics

Panel A: Total Sample (N = 2,390)

Variables	Mean	Std	Median	1Q	3Q
RD	0.052	0.037	0.048	0.017	0.069
TQ_{t+1}	1.319	1.099	0.736	0.853	1.523
TQ_{t+2}	1.320	1.104	0.730	0.858	1.524
TQ_{t+3}	1.323	1.106	0.734	0.866	1.525
ROA_{t+1}	-0.011	0.028	0.189	-0.071	0.092
ROA_{t+2}	-0.018	0.026	0.193	-0.075	0.086
ROA_{t+3}	-0.021	0.024	0.195	-0.076	0.081
$SIZE$	17.779	17.783	0.758	17.259	18.251
AGE	2.560	2.485	0.527	2.197	2.890
LEV	0.377	0.359	0.203	0.215	0.509
GRW	0.144	0.075	0.413	-0.077	0.291
MB	1.657	1.227	1.390	0.779	2.033

Panel B: IT Hardware firm (N = 1,741)

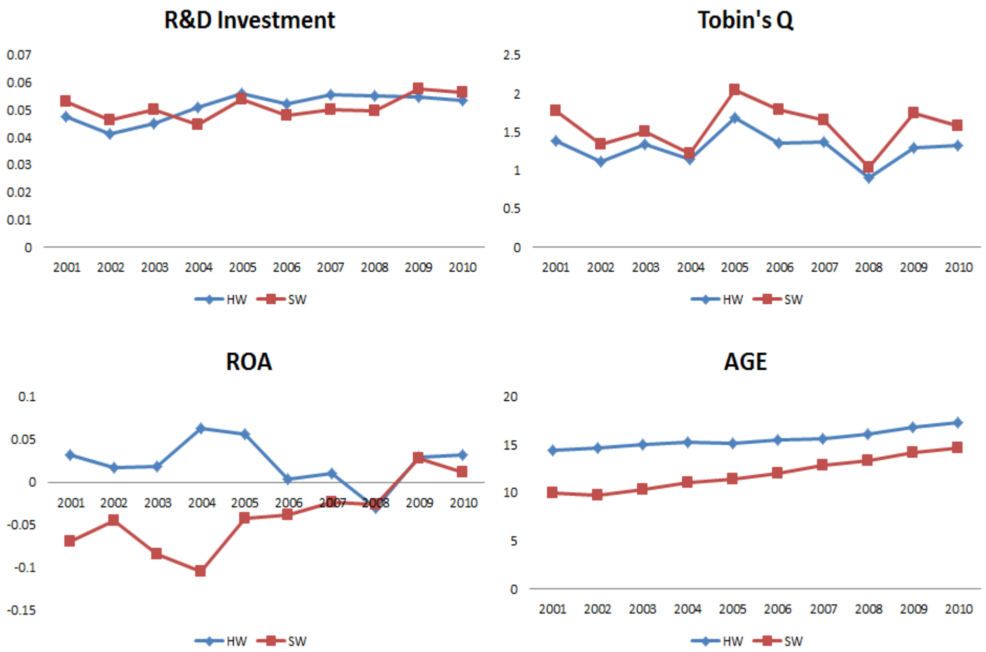
Variables	Mean	Std	Median	1Q	3Q
RD	0.052	0.039	0.046	0.019	0.068
TQ_{t+1}	1.234	1.048	0.645	0.838	1.405
TQ_{t+2}	1.235	1.050	0.640	0.843	1.408
TQ_{t+3}	1.245	1.048	0.658	0.850	1.414
ROA_{t+1}	0.002	0.032	0.180	-0.056	0.101
ROA_{t+2}	-0.006	0.029	0.183	-0.060	0.094
ROA_{t+3}	-0.010	0.027	0.186	-0.064	0.091
$SIZE$	17.859	17.857	0.724	17.353	18.313
AGE	2.612	2.565	0.544	2.197	2.996
LEV	0.389	0.377	0.199	0.231	0.523
GRW	0.162	0.084	0.438	-0.082	0.326
MB	1.537	1.160	1.274	0.756	1.838

Panel C: IT Software firm (N = 649)

Variables	Mean	Std	Median	1Q	3Q
RD	0.052	0.031	0.053	0.013	0.076
TQ_{t+1}	1.549	1.274	0.901	0.897	1.897
TQ_{t+2}	1.547	1.270	0.890	0.928	1.886
TQ_{t+3}	1.533	1.270	0.874	0.915	1.866
ROA_{t+1}	-0.044	0.020	0.209	-0.101	0.074
ROA_{t+2}	-0.051	0.020	0.214	-0.099	0.068
ROA_{t+3}	-0.053	0.020	0.213	-0.099	0.067
$SIZE$	17.565	17.526	0.804	16.958	18.089
AGE	2.421	2.398	0.450	2.197	2.708
LEV	0.347	0.319	0.210	0.173	0.486
GRW	0.097	0.057	0.332	-0.060	0.218
MB	1.978	1.488	1.621	0.865	2.433

<Where>

RD_t = R&D investment/beginning total assets at time t
TQ_{t+1} = (total asset+market value of equity-book value of equity)/total assets at time t+1
TQ_{t+2} = (total asset+market value of equity-book value of equity)/total assets at time t+2
TQ_{t+3} = (total asset+market value of equity-book value of equity)/total assets at time t+3
ROA_{t+1} = net income/beginning total assets at time t+1
ROA_{t+2} = net income/beginning total assets at time t+2
ROA_{t+3} = net income/beginning total assets at time t+3
$SIZE_t$ = natural logarithm of total assets at time t
AGE_t = natural logarithm of firm's age at time t
LEV_t = Total debt/total assets at time t
GRW_t = (sales at time t-sales at time t-1)/beginning total assets at time t
MB_t = market value of equity/book value of equity at time t
$YEAR$ = Year indicators



<Figure 1> Time Series of the Key Variables (Means are reported by year)

<Table 2> Pearson Correlation

N = 2,390												
	RD	TQ_{t+1}	TQ_{t+2}	TQ_{t+3}	ROA_{t+1}	ROA_{t+2}	ROA_{t+3}	*SIZE*	*AGE*	*LEV*	*GRW*	*MB*
RD	1.000	0.204 (0.000)	0.239 (0.000)	0.165 (0.000)	0.079 (0.045)	0.016 (0.709)	0.016 (0.731)	-0.159 (0.000)	-0.103 (0.009)	-0.232 (0.000)	0.079 (0.045)	0.146 (0.000)
TQ_{t+1}		1.000	0.541 (0.000)	0.424 (0.000)	-0.021 (0.589)	-0.010 (0.818)	-0.012 (0.788)	0.026 (0.508)	-0.025 (0.521)	-0.026 (0.503)	0.091 (0.020)	0.498 (0.000)
TQ_{t+2}			1.000	0.523 (0.000)	-0.031 (0.465)	-0.048 (0.256)	-0.036 (0.436)	0.010 (0.823)	0.008 (0.846)	-0.006 (0.880)	0.041 (0.337)	0.399 (0.000)
TQ_{t+3}				1.000	-0.084 (0.071)	-0.071 (0.127)	-0.079 (0.088)	-0.017 (0.712)	0.027 (0.559)	-0.006 (0.898)	0.073 (0.116)	0.239 (0.000)
ROA_{t+1}					1.000	0.494 (0.000)	0.401 (0.000)	0.249 (0.000)	-0.061 (0.123)	-0.227 (0.000)	0.210 (0.000)	0.009 (0.826)
ROA_{t+2}						1.000	0.484 (0.000)	0.261 (0.000)	-0.046 (0.275)	-0.209 (0.000)	0.129 (0.002)	0.051 (0.231)
ROA_{t+3}							1.000	0.280 (0.000)	-0.046 (0.327)	-0.169 (0.000)	0.030 (0.514)	0.014 (0.770)
SIZE								1.000	0.151 (0.000)	-0.075 (0.056)	0.074 (0.058)	0.018 (0.645)
AGE									1.000	0.249 (0.000)	-0.084 (0.033)	-0.058 (0.143)
LEV										1.000	-0.023 (0.556)	0.174 (0.000)
GRW											1.000	0.159 (0.000)
MB												1.000

<Table 2> shows the Pearson correlation coefficients of the variables used in the analysis. First, RD shows a positive correlation with TQ and RO. However, the significance with TQ is <Table 2> shows the Pearson correlation coefficients of the variables used in the analysis. First, RD shows a positive correlation with TQ and RO. However, the significance with TQ is at 1%, while the significance with ROA is lower. This means that there is a closer relationship between Tobin's Q and R&D investments in terms of firm performance.

When examining the relationship between the controlled variables included in a single model, there is a negligible relationship between all variables. Therefore, multicollinearity can be safely ruled out as a concern.

4.2 Analysis

<Table 3> presents the results of testing Hypotheses 1-1 and 2-1, using Tobin's Q as a dependent variable. Panel A presents the analysis based on the entire IT firms, while Panels B and C present analyses of the hardware and software firms, respectively. The positive values of all panels show that R&D investment has a positive effect on firm value. For Panel C, the value is 3.645 (4.205, 3.281) while it is lower for Panel B, at 2.140 (1.390, 1.291), indicating that R&D investment has a greater effect in the software firm. In addition, Panel D also includes the DD variable (1 for software, 0 for hardware) in order to test the significance of these differences. The value of DD×RD is 1.397 (2.605, 1.658). As this value is statistically significant, it supports Hypothesis 1-1.

These results imply that the IT firms can benefit in terms of increasing firm performance by investing more in R&D. These effects were present in both the hardware and software firms, but the effect on the software firm was greater, which means that R&D investment has a greater impact on enhancing firm value if it is a software firm.

<Table 4> presents the results of testing Hypotheses 1-2 and 2-2, using ROA (firm's accounting performance) as a dependent variable. As in <Table 3>, Panel A presents the analysis based on the entire IT firms, while Panels B and C present analyses of the hardware and software firms, respectively. The positive values of Panels A and B show that R&D investment has a positive effect on ROA, while Panel C shows an insignificant result, indicating that the effect of R&D investment on the ROA of software firms is not significant. In addition, Panel D further includes the DD variable (1 for software, 0 for hardware) in order to test the statistical significance of the differences in the values of the variable of interest in Panel B and C. The result shows that the value of DD×RD is not significant. This does not mean that the R&D activities are irrelevant to accounting outcomes, but it is probable that the R&D expense in Panel C has no impact on the ROA for software firms.

Based on the results shown in <Table 3> and <Table 4>, R&D investment was confirmed to have a significantly positive effect on the value of IT firms, showing a greater effect in the software firm. However, while R&D investment was found to have a positive effect on ROA in the hardware firm, the effect on ROA was insignificant in the software firm. In other words, in the software firm, R&D has a very positive effect on firm value but not on a firm's future

<Table 3> Hypothesis 1-1, 2-1: R&D and TQ

$$TQ_{t+1}(\text{or } TQ_{t+2} \text{ or } TQ_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 SIZE_t + \beta_3 AGE_t + \beta_4 LEV_t + \beta_5 GRW_t + \sum YEAR + \epsilon$$

Panel A: IT Total

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	2.271	6.23***	2.590	6.52***	2.702	6.24***
RD	+	2.373	7.60***	2.099	6.12***	1.671	4.32***
SIZE	-	-0.055	-2.71***	-0.074	-3.36***	-0.081	-3.34***
AGE	-	-0.067	-2.29**	-0.058	-1.85*	-0.056	-1.66*
LEV	+	0.133	1.85*	0.205	2.64***	0.221	2.61***
GRW	+	0.188	5.28***	0.077	2.01**	0.028	0.67
YEAR		Included		Included		Included	
F-value		23.39***		17.14***		14.68***	
Adjusted R^2		0.116		0.0933		0.0871	
N		2390		2041		1721	

Panel B: IT Hardware

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	2.229	5.72***	2.746	6.38***	2.787	5.78***
RD	+	2.140	6.38***	1.390	3.73***	1.291	3.03***
SIZE	-	-0.070	-3.23***	-0.094	-3.91***	-0.094	-3.48***
AGE	-	-0.023	-0.80	-0.042	-1.35	-0.056	-1.63
LEV	+	0.252	3.39***	0.319	3.94***	0.338	3.73***
GRW	+	0.225	6.54***	0.101	2.69***	0.006	0.15
YEAR		Included		Included		Included	
F-value		20.39***		13.91***		12.29***	
Adjusted R^2		0.1349		0.1014		0.0976	
N		1741		1488		1254	

Panel C: IT Software

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	0.353	0.43	0.312	0.36	0.654	0.70
RD	+	3.645	5.47***	4.205	5.85***	3.281	4.04***
SIZE	-	0.071	1.60	0.059	1.24	0.029	0.58
AGE	-	-0.069	-0.82	0.022	0.25	0.109	1.17
LEV	+	0.152	0.88	0.187	1.03	0.100	0.52
GRW	+	0.195	1.90*	0.124	1.17	0.163	1.48
YEAR		Included		Included		Included	
F-value		7.15***		6.34***		4.90***	
Adjusted R^2		0.1173		0.1117		0.0912	
N		649		553		467	

Panel D: Effect of DD on Relationship of RD and TQ

$$TQ_{t+1}(\text{or } TQ_{t+2} \text{ or } TQ_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 DD + \beta_3 RD \times DD + \beta_4 LEV_t + \beta_5 AGE_t + \beta_6 LEV_t + \beta_7 GRW_t + \sum YEAR + \epsilon$$

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	1.526	4.18***	1.869	4.71***	2.021	4.63***
RD	+	2.104	5.64***	1.423	3.47***	1.347	2.91***
DD	?	0.249	5.44***	0.175	3.51***	0.193	3.50***
RD×DD	+	1.397	2.24**	2.605	3.82***	1.658	2.13**
SIZE	-	-0.024	-1.20	-0.042	-1.90*	-0.051	-2.10**
AGE	-	-0.034	-1.15	-0.032	-1.02	-0.026	-0.76
LEV	+	0.181	2.57**	0.244	3.22***	0.243	2.91***
GRW	+	0.208	5.97***	0.094	2.52**	0.038	0.94
YEAR		Included		Included		Included	
F-value		27.93***		21.72***		16.96***	
Adjusted R^2		0.1528		0.1322		0.115	
N		2390		2041		1721	

Notes: ***, **, and * represent a significance at 1, 5, and 10 percent level, respectively.
DD: if A firm belongs to IT-software then 1; else 0.
The definitions of the other variables are presented in table 1.

<Table 4> Hypothesis 1-2, 2-2: R&D and ROA

$$ROA_{t+1}(\text{or } ROA_{t+2} \text{ or } ROA_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 SIZE_t + \beta_3 LEV_t + \beta_4 MB_t + \sum YEAR + \epsilon$$

Panel A: IT Total

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	-0.961	-10.22***	-0.859	-8.12***	-0.784	-6.73***
RD	+	0.309	3.86***	0.158	1.76*	0.215	2.10**
SIZE	+	0.056	10.85***	0.050	8.59***	0.045	7.04***
LEV	-	-0.195	-10.24***	-0.167	-7.94***	-0.130	-5.61***
MB	+	0.004	1.30	0.004	1.28	0.003	0.90
YEAR		Included		Included		Included	
F-value		19.63***		13.35***		9.66***	
Adjusted R^2		0.0921		0.0677		0.0525	
N		2390		2041		1721	

Panel B: IT Hardware

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
Intercept	?	-0.845	-7.63***	-0.653	-5.17***	-0.488	-3.46***
RD	+	0.334	3.60***	0.243	2.31**	0.276	2.29**
SIZE	+	0.049	8.12***	0.038	5.49***	0.028	3.62***
LEV	-	-0.197	-9.03***	-0.152	-6.23***	-0.117	-4.30***
MB	+	0.005	1.41	0.002	0.46	0.003	0.66
YEAR		Included		Included		Included	
F-value		13.57***		7.96***		5.15***	
Adjusted R^2		0.0859		0.0532		0.0352	
N		1741		1488		1254	

Panel C: IT Software

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	-0.948	-5.04***	-0.998	-4.83***	-1.202	-5.38***
RD	+	0.223	1.42	-0.026	-0.15	0.153	0.77
SIZE	+	0.055	5.38***	0.058	5.13***	0.069	5.64***
LEV	-	-0.199	-5.05***	-0.202	-4.72***	-0.141	-3.09***
MB	+	0.006	1.13	0.011	1.98**	0.006	0.98
YEAR		Included		Included		Included	
F-value		7.47***		6.89***		6.04***	
Adjusted R^2		0.1149		0.1135		0.1063	
N		649		553		467	

Panel D: Effect of DD on Relationship of RD and ROA

$$TQ_{t+1}(\text{or } TQ_{t+2} \text{ or } TQ_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 DD + \beta_3 RD \times DD + \beta_4 LEV_t + \beta_5 AGE_t + \beta_6 LEV_t + \beta_7 GRW_t + \sum YEAR + \epsilon$$

Variables	Expected Sign	(1) TQ_{t+1}		(2) TQ_{t+2}		‘(3) TQ_{t+3}	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
Intercept	?	-0.872	-9.15***	-0.772	-7.20***	-0.704	-5.95***
RD	+	0.307	3.21***	0.190	1.76*	0.245	2.00**
DD	?	-0.038	-3.18***	-0.032	-2.37**	-0.027	-1.81*
RD×DD	+	-0.082	-0.50	-0.188	-1.02	-0.181	-0.86
SIZE	+	0.052	9.93***	0.046	7.78***	0.041	6.34***
LEV	-	-0.205	-10.78***	-0.176	-8.38***	-0.137	-5.90***
MB	+	0.006	2.11**	0.006	1.99**	0.005	1.40
YEAR		Included		Included		Included	
F-value		18.82***		12.94***		9.17***	
Adjusted R^2		0.1006		0.0757		0.0582	
N		2390		2041		1721	

Notes: ***, **, and * represent a significance at 1, 5, and 10 percent level, respectively.
DD: if A firm belongs to IT-software then 1; else 0.
The definitions of the other variables are presented in table 1

<Table 5> Analysis Result for H3, 4: Firm Age and R&D

$$RD_t = \beta_0 + \beta_1 AGE_t + \beta_2 SIZE_t + \beta_3 LEV_t + \beta_4 ROA_t + \beta_5 MB_t + \Sigma YEAR + \epsilon$$

Panel A: IT Total

Variables	Expected Sign	(1) IT Total		(2) IT hardware		(3) IT software	
		RD		RD		RD	
		Coefficients	t-value	Coefficients	t-value	Coefficients	t-value
intercept	?	0.214	8.96***	0.163	5.80***	0.339	7.29***
AGE	-	-0.020	-10.83***	-0.025	-12.97***	-0.001	-0.13
SIZE	-	-0.006	-4.40***	-0.002	-1.43	-0.016	-6.04***
LEV	-	-0.025	-4.76***	-0.025	-4.24***	-0.053	-4.85***
ROA	+	0.029	5.35***	0.017	2.70***	0.039	3.81***
MB	+	0.006	8.26***	0.006	7.53***	0.007	5.37***
YEAR		Included		Included		Included	
F-value		27.21***		24.79***		8.24***	
Adjusted R^2		0.1331		0.1607		0.1353	
N		2390		1741		649	

Panel B: IT Hardware

Variables	Expected Sign	RD	
		Coefficients	t-value
intercept	?	0.234	9.71***
AGE	+	-0.024	-11.72***
DD	?	-0.046	-4.12***
AGE×DD	+	0.015	3.37***
SIZE	-	-0.006	-4.67***
LEV	-	-0.029	-5.54***
ROA	+	0.025	4.67***
MB	+	0.006	8.87***
YEAR		Included	
F-value		25.88***	
Adjusted R^2		0.1428	
N		2390	

Notes: ***, **, and * represent a significance at 1, 5, and 10 percent level, respectively.
DD: if A firm belongs to IT-software then 1; else 0.
The definitions of the other variables are presented in table 1

profitability. For the software firm, the overall firm value may increase through R&D activities having a positive impact on product quality, but there is a chance that this effect may not directly impact earnings (profitability). For example, Google's R&D investment may improve services of their main function such as search capabilities, but may not necessarily lead to profit-generating activities (e.g. advertisement revenue).

<Table 5> shows the regression between equation 5, 6 in order to validate hypotheses 3, 4. The first column represents the entire IT firms, with RD at time t as the dependent variable and AGE as the test variable. The variable of interest, AGE, has a negative coefficient with RD. The second column presents a similar regression analysis, but only including the software firm. As can be seen, there is an insignificant relationship between AGE and RD in the software firm. The third column presents a similar regression analysis, but only including the hardware firm. The negative coefficient indicates that in the hardware firm, R&D investments will decrease with increasing firm age. This means that Hypothesis 3, that IT firms' age will influence R&D investment, and Hypothesis 4, that hardware firms' age will influence R&D investment, can be supported by the regression analysis, but for the software firm, there exists an insignificant relationship between firm age and R&D investments.

<Table 6> Additional test for H1,2,3 and 4.

Panel A: R&D and TQ

$$ROA_{t+1}(\text{or } ROA_{t+2} \text{ or } ROA_{t+3}) = \beta_0 + \beta_1 RD_t + \beta_2 SIZE_t + \beta_3 LEV_t + \beta_4 MB_t + \sum YEAR + \epsilon$$

Variable	Exp. Sign.	(1) Total		(2) Hardware		(3) Software		(4)Total	
		TQ_{t+1}		TQ_{t+1}		TQ_{t+1}		TQ_{t+1}	
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
intercept	?	2.271	5.50***	2.229	4.91***	0.353	0.44	1.526	3.76***
RD	+	2.373	6.61***	2.140	5.36***	3.645	5.33***	2.104	5.40***
DD	?							0.249	4.98***
RD×DD	+							-1.397	1.86*
SIZE	-	-0.055	-2.41**	-0.070	-2.89***	0.071	1.57	-0.024	-1.08
AGE	-	-0.067	-2.44**	-0.023	-0.83	-0.069	-0.87	-0.034	-1.22
LEV	+	0.133	1.80*	0.252	3.26***	0.152	0.85	0.181	2.51**
GRW	+	0.188	5.41***	0.225	6.04***	0.195	2.09**	0.208	6.06***
Year Dummy		Included		Included		Included		Included	
F value		20.46***		17.83***		6.25***		24.82***	
Adj R^2		0.1156		0.1344		0.116		0.1524	
Sample		2390		1741		649		2390	

Panel B: R&D and ROA

$$ROA_{t+1} = \beta_0 + \beta_1 RD_t + \beta_2 DD + \beta_3 RD \times DD + \beta_4 SIZE_t + \beta_5 LEV_t + \beta_6 MB_t + \sum YEAR + \epsilon$$

Variable	Exp. Sign.	(1) Total		(2) Hardware		(3) Software		(4)Total	
		ROA_{t+1}		ROA_{t+1}		ROA_{t+1}		ROA_{t+1}	
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
intercept	?	-0.961	-8.86***	-0.845	-6.56***	-0.948	-4.89***	-0.872	-8.10***
RD	+	0.309	3.51***	0.334	3.41***	0.223	1.24	0.307	3.19***
DD	?							-0.038	-2.97***
RD×DD	+							-0.082	-0.46
SIZE	+	0.056	9.42***	0.049	7.03***	0.055	5.30***	0.052	8.81***
LEV	-	-0.195	-9.38***	-0.197	-8.36***	-0.199	-5.10***	-0.205	-9.76***
MB	+	0.004	1.04	-0.845	-6.56***	0.006	1.00	0.006	1.64
Year Dummy		Included		Included		Included		Included	
F value		17.01***		11.76***		6.46***		16.60***	
Adj R^2		0.0917		0.0853		0.1135		0.1002	
Sample		2390		1741		649		2390	

Panel C: AGE and RD

$$RD_t = \beta_0 + \beta_1 AGE_t + \beta_2 DD + \beta_3 AGE \times DD + \beta_3 SIZE_t + \beta_4 LEV_t + \beta_5 ROA_t + \beta_6 MB_t + \sum YEAR + \epsilon$$

Variable	Exp. Sign.	(1) Total		(2) Hardware		(3) Software		(4)Total	
		RD		RD		RD		RD	
		Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
intercept	?	0.214	8.89***	0.163	5.58***	0.339	8.27***	0.234	9.83***
AGE	-	-0.020	-11.86***	-0.025	-13.46***	-0.001	-0.14	-0.024	-12.83***
DD	?							-0.046	-4.14***
RD×DD	+							0.015	3.48***
SIZE	-	-0.006	-4.40***	-0.002	-1.38	-0.016	-6.64***	-0.006	-4.73***
LEV	-	-0.025	-4.95***	-0.025	-4.30***	-0.053	-5.05***	-0.029	-5.65***
ROA	+	0.029	4.54***	0.017	2.18**	0.039	3.60***	0.025	3.92***
MB	+	0.006	6.95***	0.006	5.68***	0.007	4.98***	0.006	7.32***
Year Dummy		Included		Included		Included		Included	
F value		23.79***		21.68***		7.20***		23.00***	
Adj R^2		0.1328		0.1602		0.1339		0.1425	
Sample		2390		1741		649		2390	

Notes: ***, **, and * represent a significance at 1, 5, and 10 percent level, respectively.
DD: if A firm belongs to IT-software then 1; else 0.
The definitions of the other variables are presented in table 1

Column (2) and (3) present the possible differences in R&D expenses between hardware and software firms based on training programs. Panel B serves to revisit the statistical significance of the difference in the values of the variable of interest in Panel A's (2) and (3). As a result, the DD×AGE variable shows statistically significant positive values (β = 0.015, t-value = 3.37). This result indicates that an increase in training programs has a greater impact on the decrease in R&D expense for the hardware firm, and the effect of R&D is supported with more robustness.

In general, firms in the hardware firm concentrate on improving technology developed at an early stage. For this reason, it is natural for R&D investments to gradually decrease over time. In the software firm, continuous development is required, suggesting that R&D investments should remain steady. Unique technologies are more easily adopted by competitors in the software firm than in the hardware firm; this characteristic necessitates continuous innovation for survival in the software market.

4.3 Additional test

In case data includes samples over several years as the data shown in this study, the correlation between time series is likely to have effects on the results of study. For the additional test, we performed Newey-west test. As a result of performing the Woodridge test to examine serial correlation problem in the model, serial correlation problem was found to occur at 1% level. We retested Hypothesis 1 using the method of Newey-West correction [1987], which provides t value after adjustment of heteroscedasticity and cross section-time series dependency problems.

The result of the additional test <Table 6> was qualitatively identical to the existing result, and we only showed dependent variables TQ t+1 and ROA t+1 in the paper.

Ⅴ. Discussion and Conclusions

This study examined the roles and characteristics of R&D investment with regard to its effect on firm performance in the IT industries. The results showed that firm performance increases with increasing R&D investment. In particular, the effect of R&D investment on ROA and Tobin's Q was investigated; initial results showed R&D investment had a positive effect on both hardware and software companies. Parsing the industry into hardware and software companies, the hardware firms showed a similar trend as the IT firms as a whole. In the case of the software firm, R&D investment was positively correlated with Tobin's Q but not with ROA. This result can be attributed to the fact that, in hardware companies, product quality is very well reflected by technological level and directly affects the profitability of the firm, whereas the software firm requires additional activities (advertising, establishment of paid services), not to say that technology is not a critical factor, but it has minimal direct effects to the profitability of the firm. When comparing the effect of R&D investment on firm value between the hardware and software firms, there was a greater positive effect in the software firm. This is because software companies deal with intangible assets, and places less importance in facilities, distribution, and other infrastructure. Also because of its faster speed of technological development, the effect of R&D investment on firm value is greater in the software rather than in the hardware firm.

The relationship between firm age and R&D investment was also analyzed. When looking at the IT firms as a whole, increasing firm age leads to a decrease in R&D investment, as accumulated technology makes it easier for firms to utilize their gained experience in place of R&D. When breaking this analysis down into the hardware and software companies, the former showed a decrease in R&D investment with increasing age, but this was not the case for software firms. One of the characteristics that make the software firms unique is the fast pace of technological development. This makes it harder for companies to utilize accumulated experience in their operations. In addition, duplication of technology is easier in the software compared to hardware environments, and a company's survival thus inevitably requires active and continuous investment in R&D, regardless of its age. The fact that IT is a high-tech industry means that R&D investment is crucial to a firm's business performance, and this study confirmed that a learning effect was present in R&D investments. However, this type of characteristic may not hold in unique sectors within the IT sectors, such as software companies.

This study makes several unique contributions: first, in spite of the sizable growth of R&D investment in IT industries, a degree of skepticism concerning R&D investment has recently emerged. Under this situation, we empirically examined and revealed that R&D investment in IT industry is positively correlated with firm performance, and therefore would appear to be a necessary investment for any firm's future profitability.

In addition, although IT hardware and software industries have different characteristics respectively, there was no research and discussion addressing this particular issue. To address this, we tested how the effect of R&D investment differs between IT hardware and software environments. Finally, prior studies mainly focused on the R&D's effect on profit and revenue aspects. However, this study used Tobin's Q which is a better indicator for measuring R&D performance. Therefore, this study provides a novel, better and effective measure of a firm's value.

On the other hand, firms are given the information that in the software industry, a corporate value may increase with no rise in accounting income even though investment costs are raised in the field of research and development. Therefore, this study suggests that multilateral evaluation of corporate values beyond the visible net profit be carried out and that through the evaluation, inward and outward investments be made.

It is suggested that long-lived firms are also required to make persistent efforts for research and development without relying merely on existing knowledge and success experiences because the software industry has a short life of knowledge and a tremendous growth rate. On the contrary, new firms of the software industry, in case they possess high technical skills, are considered more probable to win competition over existing companies, compared to those of the hardware industry.

Besides, this study will be beneficial to government efforts to understand the role of IT firms contributions to the wider economy, and provide a framework for support through effective centralized policy. In addition, investors will benefit from this study when considering the relationship between R&D investment and firm performance. Furthermore, IT firms will be able to utilize the results of this study when evaluating performance and making decisions.

This study has also several limitations. First possible limitation is data source drawn from financial statements. For example, R&D investments should be differently categorized as IT R&D investment and other R&D investments. Therefore, further research would better to use specific R&D investments, such as IT R&D investment.

In addition, it would be better placed, if further research examines R&D investment effects on firm performance depending on firm governance structure, capital structure, and management strategy.

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