Further Examinations on the Financial Aspects of R&D Expenditure For Firms Listed on the KOSPI Stock Market

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국내 KOSPI 상장기업들의 연구개발비 관련 재무적 요인 심층분석

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Abstract The study examines corporate research & development (R&D) expenditure in modern finance. Firms may face one of the essential issues to maintain their optimal levels of R&D expenditures in order to increase corporate profit. Accordingly, financial determinants that may influence R&D spending are statistically tested for firms listed on the KOSPI stock market during the period from 2010 to 2015. Financial determinants which may discriminate between firms in high-growth and low-growth industries are examined on a relative basis. Explanatory variables including one-period lagged R&D expenses (Lag_RD), cross-product term between the Lag_RD and type of industry (as a dummy variable), and advertising expenses (ADVERTISE) significantly influenced corporate R&D intensity. Moreover, high-growth firms in domestic capital markets showed higher Lag_RD, profitability (PROF) and foreign equity ownership (FOS) than their counterparts in low-growth sectors, whereas low-growth firms had higher market-value based leverage (MLEVER) and ADVERTISE. Overall, these results are expected to influence decision-making of firms concerning the optimal level of R&D expenditure, which may in turn enhance shareholder wealth.

요 약 본 연구에서는 경영학 재무 분야 중 국내 유가증권 시장 상장기업의 연구개발비에 관한 2가지 가설이 수립, 검정되었다. 기업의 목표인 이윤 극대화라는 관점에서, 동 연구개발비의 최적 수준을 유지하는 것이 실무적으로도 중필수적 요인이라고 판단된다. 이와 관련하여, 본 논문의 첫 번째 가설에서는 국제금융위기 이후인 2010년부터 2015년의 표본기간 동안, 국내 KOSPI 유가증권 시장에 상장된 기업들을 표본 대상으로 동 연구개발비 지출에 관한 재무적 결정요인들이 통계적으로 분석되었다. 또한, 이와 관련된 두 번째 가설 검정에서는 동 표본기업들을 대상으로 이들을 상대적 고성장산업과 저성장산업 그룹으로 2분화하여 양 그룹 간의 재무적 차이점에 대한 재무적 결정 요인 분석을 시행하였다. 동 가설검정 결과와 관련하여, 전기의 연구개발비 비율, 산업더비변수와 전기의 연구개발비 간의 교차효과, 그리고 광고비 등 3가징 요인들이 (당기의) 연구개발비 (비율)에 통계적으로 유의한 영향을 주는 설명변수들로서 판명되었다. 또한, 고성장산업 소속 KOSPI 상장기업들은 비교그룹인 저성장산업 소속의 기업들과 비교하여, 전기의 연구개발비 비율, 수익성, 그리고 외국인 지분율 등에서 상대적으로 높은 수준을 유지한 것으로 실증적으로 분석되었고, 반면에, 후자인 저성장산업 소속 기업들은 시장가치 기준의 부채비율과 광고비 등에서 높은 수준을 유지한 것으로 판명되었다. 종합적인 관점에서, 본 연구 결과는 향후 기업 경영의 목표인 주주의 부의 극대화를 위한 방안 중 하나인, 연구개발비의 최적 수준을 규명하기 위한 측면에 응용될 수 있을 것으로 기대된다.

Keywords : Binary Dependent Variable Model, Global Financial Turmoil, Korean Domestic Market, KOSPI-listed Firms, Research & Development (R&D) Intensity, Static Panel Data Model

1. Introduction

The study addresses one of the academic subjects in debate, which may draw much attention from the perspective of academics and practitioners in relation to corporate expenditures in modern finance. That is, among various types of investments or expenditures implemented by corporations to increase firm value, the level of research and development (hereafter, R&D) expenditures is one of the current issues of concern, which may be excessive or insufficient to maximize shareholders' wealth. As an objective of performing the study, it empirically conducts to identify any statistically significant financial factors that may influence the level of corporate R&D spending for firms listed in KOSPI (Korea Composite Stock Price Index) stock market in the post-period of the global financial turmoil (from 2010 to 2015). The present study is an extension of the preceding research conducted by [1] which examined the existence of an optimal level of R&D investments with fundamental financial attributes to influence the level Meanwhile, it was recently reported by Ministry of Science and ITC (Information, Communication and Technology) of Korean government that total amount of R&D expenditures were recorded as KRW 65.9594 trillion (=U$ 58.3 billion) and KRW 69.4055 trillion (=U$ 59.8 billion) for the years, 2015 and 2016, respectively, as in [2] and [3]. These amounts were top-tier (i.e., 6th and 5th from the top) amongst all OECD (Organization for Cooperation and Development) members during the same years. The ratios of R&D expenditures over national GDP (Growth Domestic Product) were recorded as 4.23% and 4.24%, which were 1st and 2nd globally. Moreover, the proportion of total R&D outlay invested by corporate sector in Korea was estimated as 77.7% which surpassed its counterparts in corporate sectors such as China (76.8%), the U.S. (71.5%) and Germany (68.7%). [3] Major motivations to perform the study, which may be different from those in the previous studies on the

subject are described as follows: First, relatively little attention may be paid to the subject of R&D in the Korean emerging market, to date, since the global financial turmoil begun in 2008. On the contrary, there are relatively voluminous researches had been conducted for firms belonging to the advanced capital markets. Therefore, results obtained from the study are anticipated to be applied to firms in other emerging capital markets inclusive of the domestic market, after identifying financial factors to determine the level of corporate R&D intensity. Second, it may be essential or valuable to further detect any relationships between corporate R&D intensity and proposed explanatory variables which are supported by theory and/or empirical results in finance. That is, in the present study as an extended one of [1], wider spectrum of financial variables are employed and tested than those in [1] for further investigation. To specify, various new or modified financial variables (i.e., total 11 variables) based on those in [1] have been employed to account for the level of corporate R&D. Moreover, additional econometric estimations such as robust regression and stepwise regression models to test for the relevant hypotheses below, were applied to the KOSPI-listed sample firms for the purpose of comparability and consistency with those in the previous studies. Finally, the outcome of the study with more robustness is expected to be utilized in searching for the optimal level of R&D intensity to enhance firm value from the shareholders' perspectives, as described in [1].

2. Literature Review

[4]tested benefit or detriment of a firm's R&D investments in terms of stock price with utilizing the U.S. sample data during the period from 1979 to 1985. In the study, systematic and statistically significant factors which may influence a change of stock price were examined on the basis of the type of R&D costs. The results showed that announcements for the increase

of R&D expenditures were, on average, positive information to increase a firm's market capitalization. Moreover, results of earnings with positive or negative amounts were found not to be statistically different to increase firm value in the long-term. In the study of [5], it was hypothesized such that corporate manager has an option to choose among R&D investment opportunities based on the three scenarios: As for the first and the third scenario, a manager may choose to accept all R&D investments opportunities regardless of gains or losses related to net present value (NPV) projects. However, the second scenario is associated with only a part of R&D investment opportunities which management should consider, since the difference between anticipated earnings before R&D investments and corporate income target, is smaller in amount than the total amount needed to invest all the possible R&D opportunities. The study provided evidence that relative R&D ratio that was defined as percent change in R&D spending, was, overall smaller for the sample observations for the second scenario than their counterparts classified into the first and the second scenarios. [6] tested several hypotheses that corporate earnings are artificially adjusted by management in the short-term if projected earnings seem to be deviated from its original target goal. Multiple regressions covering the sample period from 1972 to 1983 were applied to the U.S. sample firms to derive estimators for unexpected costs. The study demonstrated evidence that there was an almost linear relationship between a firm's unexpected R&D expenses and corporate earnings. [7] examined a relationship between a firm's stock return and its R&D spending. Both measures such as the ratio of R&D expenditures to sales and to market value of equity, were separatedly adopted to test for a degree of market valuation in relation to R&D investments. When using the former ratio, the result showed that there was no statistically significant difference between the firms with and without making R&D investments in terms of market reaction. Morevover, [7] presented the findings

that a glamour stock with higher R&D outlay statistically earned a relatively high rate of stock return in comparison with its counterpart with a lower R&D outlay. Meanwhile, the study done by [8] tested for possibilities of market under- or over-reaction relative to long-term stock rate of return as well as operating performance in the post-period of announcement of corporate R&D expenditures. In regard to the results obtained from the tests to examine statistically significant abnormal rate of returns for the sample cases, the alphas in the predicted models revealed their significances across allo the sample groups inclusive of the full sample, the 5-year sample, the rolling regression approach sample and the delisted-adjusted sample one. The study conducted by [1] examines the existence of optimal level of corporate R&D expenditures for KOSPI-listed firms in the Korean capital market. The study tested primary hypotheses related to corporate R&D activities and also financial determinants that may influence the level for KOSPI-listed firms. Overall, the sample firms seems not to statistically attain to their optimal levels of R&D expenses at the intra-industry level, even though there were statistically significant differences at the inter-industry level. Moreover, three explanatory variables such as R&D expenses of the prior fiscal year, corporate profitability and Tobin's Q, were statistically significant to account for the level of corporate R&D spending. The study presented by [13] indicated that there has been an increasing trend in R&D outlay in advanced or emerging capital markets during the era of the 70s' and 80s'. Regression models were applied to examine a relationship between annual operating income and R&D expenditure as an explanatory variable. The average duration for benefits arising from R&D outlay for the chemical and pharmaceutical industries was estimated at 9 years, whereas the duration of R&D benefits in the dometic scientific instruments industry was the shortest at 5-year period. Moreover, the study provided evidence that profitability measured by return on equity (ROE),

seemed to be larger than reported ROE for firms in a rapid growth rate in terms of R&D spending. The study by [14] tested an issue related to R&D investments, which was classified into two types of firms (i.e., high-tech vs. low-tech firms). They hypothesized that investors in the U.S. capital market may favorably respond to positive prospects of a high-tech firm's R&D investments in terms of stock returns before it announces a SEO (seasoned equity offerings) plan. Among the proposed variables in the study, the variable of discretionary R&D investments as well as stock market return showed positively significant impacts on the dependent variable of CAR (Cumulative Abnormal Return). However, the other variables such as ROA, Tobin's Q, offer size, volatility, and percent of secondary shares, did not have important role to determine CAR in the statistical context. They concluded that a firm may experience a higher rate of return on the very day of the SEO announcements, given that it spends positive discretionary R&D expenditures.

3. Data Collection and Hypothesis Postulation

3.1 Data Sampling and Variables Selection

The section describes the criteria for the data selection and variables inclusive of the dependent and the explanatory variables to perform relevant hypothesis tests in relation to corporate R&D expenditures. As described above, the study utilized the same criteria for the data selection criteria as those in [1] as an antecedent of the present study. The following table, [Table 1], describes the criteria to select the final sample data.

Table 1. Data sampling criteria

Description for selecting KOSPI-listed sample firms (2010-2015)
1. Data for each variable employed in the study are available for at least six years from 2010 to 2015.
2. Sample firms were listed in the KOSPI stock market at the end of the fiscal year, 2015.
3. Data should be included in the whole population of the KisValue database sourced from the NICE.
4. Firms in the financial and regulated industries are excluded in the final sample data.

To specify, the period during which the sample firms were selected covers from 2010 to 2015 (for 6 years) to mitigate any spillover influence associated with the unprecedented global financial crisis, as described in [1]. All the financial data for each firm were collected on the basis of consolidated financial statements, if applicable. For reference, the financial data for R&D expense for the year, 2010 was used as a base one to formulate one-period lagged R&D cost that is one of the explanatory variables employed in the models, as explained below. To summarize, total number of the sample observations which satisfy the aforementioned criteria, are 613 firms across total 24 domestic industries in Korean capital domestic market. In particular, out of total number of sample observations (i.e., 613 firms in 24 industries x 5 year annual data (from 2011 to 2015) = 3,065), 1,740 firms were included in the 13 industries were classified into the high-growth ones on the basis of product characteristics that are inclusive of the pharmaceutical and the electric & electricity industries, while the other firms (i.e., 1,325 ones) were categorized into the 11 industries as low-growth ones. For reference, the data of the year, 2010 were not included in the models since they were used as basis when estimating one-year lagged data, as described.

Table 2. Definition and symbol of variables

Definition	Symbol	Measurement
R&D Intensity: [1],[4],[7]	DV (Dependent Variable)	(R&D Expenses) / Sales
Interaction between high-growth Firm and R&D Intensity$_{t-1}$: [1], [4]	INTERRD	Dummy Variable on High-growth Firm x (R &D Expenses$_{t-1}$ / Sales$_{t-1}$)
Firm Size: [1],[4]	SIZE	Natural Logarithm of Sales Amount
Market-value Based Leverage: [1], [14]	MLEVER	Book value of liabilities / (Book Value of Liabilities + Book Value of Preferred Equity + Market Value of Common Equity)
Profitability: [13]	PROF	[EBIT (i.e., Earnings Before Interest & Taxes) + Depreciation & Amortization + R&D Expenses)] / Total Assets
Growth	GROWTH	(Market Value of Common Equity + Book Value of Preferred Equity) / Book Value of Equity
Change in Cash Liquidity	CASHHOLD	[(Cash & Cash Equivalents)$_t$ - (Cash & Cash Equivalents)$_{t-1}$] / Total Assets
Foreign Ownership: [1]	FOS	Foreign ownership in common Equity
Business Risk	VOLATILITY	3.3 x (EBIT / Total Assets) + 1.0 x (Sales / Total Assets) + 1.4 x (Net Income / Total Assets) + 0.6 x (Market Value of Equity / Book Value of Equity)
Change in Tangible Assets	TANASSET	(Tangible Assets$_t$ - Tangible Assets$_{t-1}$ / Total Assest$_t$)
Advertising Expenses: [13]	ADVERTISE	Advertising Expenses / Total Assets

<Note> The number in [ ] indicates a reference number in References, from which each corresponding variable is cited.

To recap, total number of explanatory variables employed in the models, was eleven variables which may comprehend more broad financial aspects than those of the preceding study, [1], in relation to corporate R&D outlay. Regarding the dummy variable composing the interaction term with one-period lagged variable of R&D intensity, (i.e., Lag_RD), it was assigned as "1" for a firm belonging to the high-growth

industry, but, "0", otherwise. Meanwhile, alternative measure of business risk, VOLATILITY, which had also been used in [9], was adopted as a proxy to represent the risk in the study.

3.2 Hypothesis Postulation and Methodologies

With respect to the hypotheses that are empirically tested in relation to corporate R&D expenditures, two primary (null) hypotheses are postulated as follows:

H1$_0$: During the period (i.e., from 2010 to 2015) after the global financial turmoil ocurred in 2008, there exist no statistically significant financial factors to influence corporate R&D expenditures for firms listed in the KOSPI stock market.

As for the empirical methodologies to test the first hypothesis, static panel data model was applied to account for the distribution of cross-sectional and time-series data, which was accompanied by robust regression model to minimize possible influence of outliers and/or heteroscedasticity.

H2$_1$: Financial determinants that may affect corporate R&D expenditures for the KOSPI-listed firms in high-growth industries may be statistically different from those of their counterparts in low-growth industries during the investigated period.

In theory of modern finance, firms in the former sector (i.e., high-growth industries), are presumed to have more investment opportunities to be supported by R&D expenditures than their counterparts in the latter sector (i.e., low-growth industries). As for the methodologies to test for the hypothesis, logit and probit models are applied to the sample firms, along with the complementary log-log (i.e., Clog-log) model with ascending and descending orders, that follow the assumptions of an extreme-value distribution of a disturbance term, as presented in [10].

4. Analysis and Discussion

4.1 Results of the Hypothesis Tests

In regard to the results from the first hypothesis test, they are listed in [Table 3].

Table 3. Results of financial determinants (IDV) to affect corporate R&D spending for KOSPI-listed firms

IDV	Estimated coefficient from static panel data model (fixed effects model)	Estimated coefficient from robust regression model	Estimated coefficient from stepwise regression model
Constant	-0.003	-0.0001	0.003*
Lag_RD	0.203*	0.953*	0.705*
INTERRD	0.084**	-0.003*	0.228*
SIZE	0.0004	0.00001	(N.A.)
MLEVER	0.002	-0.00001**	-0.002*
PROF	0.008*	0.00001	(N.A.)
GROWTH	0.001*	-0.00001	0.0004*
FOS	0.003	0.00001	(N.A.)
CASHHOLD	0.002	0.0001	(N.A.)
VOLATILITY	-0.002*	0.00001	-0.001*
TANASSET	-0.0004	-0.00001	(N.A.)
ADVERTISE	0.143*	-0.0007**	0.02*

<Note1> * and ** indicate a statistical significance at the 5% and 10% levels, respectively.
<Note 2> (N.A.) denotes that the corresponding IDV is not statistically significant at the 5% for entry into the model.

Based on the outcome in the table, fixed effects model was finally chosen as the "best" one amongst fixed effects, random effects and pooled OLS ones in the context of static panel data model. To specify, since all of the *a posteriori* specification tests such as Wald (F) test (F=3.36 (p-value<0.0001)), Breusch-Pagan test (m=7.48 (p-value=0.0062) and Hausman test (m=1,362.80 (p<0.0001)) were not accepted at the 1% level in the study, the fixed effects model was finally selected as also guided by [11]. Moreover, in order to enhance the validity of the results, stepwise regression model controlled by the 5% level of statistical significance for entry and deletion levels, was employed to mitigate or reduce the issue of multicollinearity among the explantory variables. To illustrate, F-value, adjusted R-square of the model were estimated at 3,326.35 (p-value<0.0001) and 86.69%, respectively.

Among the eleven variables in [Table3], Lag_RD, INTERRD, and ADVERTISE showed their statistically significant effects on the level of R&D expenses across the three models.

Meanwhile, the consequences of the second hypothesis test is depicted in [Table 4].

Table 4. Results of binary dependent variable models to identify discriminating factors between the high-growth and low-growth industries in R&D costs

IDV	Logit	Probit	Clog-log
Constant	1.42	0.75	0.26
Lag_RD	99.05*	44.02*	29.86*
SIZE	-0.04	-0.02	-0.009
MLEVER	-1.20*	-0.74*	-0.76*
PROF	4.26*	2.79*	4.16*
GROWTH	-0.01	-0.006	-0.001
FOS	1.26*	0.71*	0.55*
CASHHOLD	-0.26	-0.25	-0.53
VOLATILITY	-0.02	-0.03	-0.09**
TANASSET	-0.14	-0.07	-0.05
ADVERTISE	-13.96*	-7.48*	-7.04*
Goodness of Fit	593.67*	552.74*	502.57*

<Note 1> * and **: Significant at the 5% and 10% levels with respect to the chi-square test.
<Note 2> Coefficients were estimated by the method of maximum likelihood (ML). The test for overall goodness of fit was performed by the likelihood ratio(LR) test, while the Wald test was used to test for the significance of each individual coefficient.

As shown in [Table 4], financial components such as Lag_RD, MLEVER, PROF, FOS and ADVERTISE did show their statistically significant roles in discriminating between firms in the two comparison sectors across the entire models. One of the explanatory variables, INTERRD, has not been included in the models to test for financial differences between firms in high-growth and low-growth sectors, due to the possibility of quasi-complete separation of the sample data as indicated in the output by SAS (9.4 version) program. Moreover, to run the binary dependent variable models, probability modelled was set to "1" if a firm belonged to high-growth industry. "0", otherwise.

4.2 Discussion

As for the financial implication based on the empirical findings in [Table 3], the statistically significant and positive relationship between corporate

R&D intensity and Lag_RD was consistent with the findings of [1] and [6]. As presented in [1], the consequence may confirm that KOSPI-listed firms tend to keep or stick to their constant levels of R&D intensity during the sample period on an annual basis. Consequently, corporate policy related to annual R&D investments may need to be more flexible from the their previous levels, (i.e.,Lag_RD), given the dynamics and sensitivities of global economic environments, as also described in [1]. Furthermore, coupled with the results reported in [Table 4] below, the phenomenon seems to be more serious for firms in high-growth sector inclusive the high-tech industries that are likely to be heavily exposed to the changes of the global market conditions. Second, the importance of the interaction term, INTERRD, with a positive sign (+), corroborates the financial interpretation associated with Lag_RD. That is, it empirically indicates that corporate R&D intensity in a current year may be positively related with that of the previous year for KOSPI-listed firm engaged in high-growth businesses or industries. In the meantime, it was interesting to identify a positively significant impact of advertising expenses, ADVERTISE, to corporate R&D intensity in Korean capital market. which has been rarely tested in the previous literature. In modern finance, both excessive R&D spending and advertising expenses are also associated with a possibility of moral hazard incurred by corporate management. Accordingly, the positive linkage between the two expenses may suggest moral hazzard supported by excess cash holdings accumulated by KOSPI-listed firms in the domestic capital market. Alternatively, it is plausible that these expenses are also utilized by a corporation as one of the major tools to save corporate taxes by reducing the amount of operating profit.

In regard to the second hypothesis tests, the followings are financial implications in relation to significant variables as reported in [Table 4]. Besides the discriminating power of Lag_RD between firms in high-growth and low-growth sectors as explicated above, MLEVER showed its statistical importance to divide the firms into the two sectors in the financial aspect. That is, if a firm increases a market-value based leverage ratio, the probability to be classified into the latter sector, (i.e., low-growth industry) will enlarge. The phenomenon is supported by the conventional finance theory such that firms in high-growth sectors inclusive I/T related industries, tend to have higher volatilities of operating earnings than their counterparts in low-growth one such as the mature industry, as presented in [12]. Accordingly, it may be rational to maintain lower leverage ratio to decrease a possibility of corporate bankruptcy. Second, PROF is defined as the ratio of EBIT, depreciation & amortization and R&D expenses over total assets in the study. It may indicate that R&D expenses spent by high-growth firms are larger than their counterparts by considering the positively significant coefficient of Lag_RD in the models and the stagnant condition of the global economy in the post-period the financial turmoil. Third, FOS as a proportion of foreign ownership in equity, showed its positive and pronounced discriminating impact across the models. This may, to a larger extent, arise from the fact that most high-growth firms are export-oriented ones which may need a wide diversity of information to effectively perform their overseas businesses. Subsequently, coupled with the fact that a majority of firms in the high-tech industries are equipped with relatively sophisticated technologies, they may expect to utilize business information and know-hows provided by foreign (institutional) investors, as also presented in [1]. Finally, It was empirically demonstrated that a firm spending larger advertising expenses, ADVERTISE, has a higher probability to be classified into a low-growth firm in the domestic capital market. The result is in compatible with the contemporary management theory presenting that firms in a mature stage tend to have a capability to allocate more funds (inclusive of advertising expenses) associated with more stable cash flow than their counterparts in the growth stage.

4. Concluding Remarks

This study addresses one of the financial issues in an active debate, in relation to corporate R&D intensity for KOSPI-listed firms after the global financial turmoil. Two primary hypotheses were postulated and tested. First, it was to identify financial determinants of R&D intensity, which is, to a larger extent, an extension of the preceding research of [1]. Amongst total 11 explanatory variables, Lag_RD, INTERRD and ADVERTISE showed their significant impacts on the level of corporate R&D intensity. Second, it was interesting to detect the consequence that high-growth firms may overall possess the financial attributes of higher Lag_RD, PROF and FOS than those of low-growth firms, while the latter group may have large MLEVER and ADVERTISE.

Even if the study may empirically suffer from legitimate and redundant weaknesses, the results of the study may provide some valuable suggestions for future studies. For instance, separate tests categorized by the size of the firms may be warranted for further investigations for R&D intensify, given that only top 5 and top 20 firms out of 100 domestic firms constituted about 37.7% and 51.6% of total corporate R&D expenditures in 2016, as reported in [3].

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<Research Interests>
Corporate Finance, M&A, Valuation, Int'l Finance