Macrothink Institute™

Asian Journal of Finance & Accounting
ISSN 1946-052X
2020, Vol. 12, No. 1

A Reexamination of Firm's R&D Expenditure Behavior

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Received: March 1, 2020 Accepted: May 18, 2020 Published: June 1, 2020

doi:10.5296/ajfa.v12i1.16968 URL: https://doi.org/10.5296/ajfa.v12i1.16968

Abstract

Knowledge acts as a crucial element in economic activities. For knowledge-intensive business, R&D activities maintain market competitiveness and create new firm value. R&D expenditure indeed brings forth potential growth opportunities for firm value although the growth may take a long time to achieve. Apart from that, it usually accompanies problems of agency costs and asymmetric information in daily firm operations, which, in turn, may offset the certainty of a firm's increasing value. This study examines the decision-making on optimal R&D expenditure for listed firms in Taiwan. From January 1986 to December 2013, the data of all the listed firms excluding financial, insurance, and securities firms have been analyzed. In addition, to further explore the differences in decision-making among different macroeconomic conditions, industrial attributes and firms' characteristics, we divide all samples into subsamples to reexamine. The empirical findings indicate that firms may weigh the cost and benefit of R&D expenditure in its decision, but the driving factor lies in firm's return on assets (ROA), potential growth opportunity, and capital structure.

Keywords: Firm value, Agency Problem, Asymmetric Information Research, and Development (R&D) Expenditure

JEL classification: G32, G34, O32

1. Introduction

People generally agree that R&D innovation activities hold a key position—that of maintaining market competitiveness and creating new firm value in knowledge-intensive enterprises. R&D expenditure can indeed bring about potential growth opportunities for firm value; however, cultivating the advantages of R&D innovation requires long-term cooperation. Therefore, how firms weigh the benefits and costs to make the most appropriate decision of R&D expenditure is an important issue.

According to statistics from the Indicators of Science and Technology of the Republic of China, issued by the Ministry of Science and Technology, the proportion of Taiwan's R&D expenditure to GDP has increased year by year since the time it exceeded 2% in 2001 and has increased to more than 3.1% since 2012. Therefore, the trend at home and abroad and the promoted national policies all advocate that R&D should be the main source of power for industrial upgrading and approve that the absolute amount of R&D expenditure plays a direct extra role in global industry competition. With respect to the research on R&D expenditure and firm value, scholars found that the increase in R&D expenditure has a positive impact on firm share price, verifying that R&D activities do help to create future earnings and cash flows and increase firm value(Hirschey and Weygandt, 1985; Bublitz and Ettredge, 1989; Chan, Martin, and Kensinger, 1990; Kothari and Zimmerman,1995).

However, Morris, Teisberg, and Kolbe (1991) proposed two risks threatening the future growth opportunities and real cash income in the R&D plan. If the plan failed, the huge expenditure would cause great losses to firm surplus. For example, Jensen (1993) found that most R&D plans that had been conducted failed to earn profits as expected, but investors' high expectations of profitability from R&D activities may cause firm stock price to be overvalued. However, in the accounting statements, when the expended annual R&D expenditure (included in the income statement under the subject of the profit and loss account) fails to consider the economic added value brought about by R&D activities, it may lead to underestimated firm value in the accounting surplus. Hall (1993) and Porter (1993) also proposed that because the benefits of R&D plans take a long time to generate investment returns, investors taking reference from the distorted accounting statements may overlook future firm value. Such short-sighted capital markets may also trigger agency problems between managers and shareholders. Empirical studies found that managers have a strong incentive to reduce the current R&D or other long-term expenditures to improve the firm's short-term performance; however, this will be inevitably inconsistent with the goals of shareholders who pursue long-term interests of the firm, resulting in related agency costs(Baber, Fairfiled, and Haggard, 1991; Dechow and Sloan, 1991; Murphy and Zimmerman, 1993).

The R&D expenditure and information asymmetry between managers and shareholders can also not be ignored. Aboody and Lev (2000) found that insiders in firms with strong R&D capability earn more profits than those in firms that do not conduct R&D activities, indicating that the problem of R&D expenditure and information asymmetry between managers and shareholders does exist.

Therefore, there is still no specific or effective method available in practice or academic research as to whether firms should always maintain a certain amount of money each year as an innovative R&D budget or maintain a certain ratio according to different characteristics and differences of the firms. To effectively control and allocate R&D resources, it is the most important research purpose of this study to find an effective measurement indicator system that can be used in Taiwan.

The rest of this paper is organized as follows. Section 2 presents a review of the literature on the benefits of firm value brought about by R&D expenditure, the cost of agency problem, and that of information asymmetry, while Section 3 provides our research design and empirical models. Section 4 presents the empirical results of this work, and Section 5 then gives the conclusions.

2. Literature Reviews

According to Standard No. 2 issued by the Financial Accounting Standards Board, research is planned search or critical investigation that is aimed at discovering new knowledge with the hope that such knowledge will be useful in developing a new product or service or a new process or technique or in bringing about significant improvement to an existing product or process. Development is the transaction of research findings or other knowledge into a plan or design for a new product or process or for a significant improvement to an existing product or process, whether intended for sale or use. Nason (1981) defined research and development (R&D) as a planned new knowledge activity that systematically develops and improves existing technologies and products and converts the results or new knowledge into new products and processes. The main purpose of this study is to explore how firms balance growth benefits and information asymmetry and agency problems brought about R&D expenditure, to obtain the optimal level of R&D expenditure. Therefore, the relevant literature review is based on the impact of R&D expenditure on the firm, and the following aspects are analysed according to R&D expenditure and firm value, information asymmetry, and agency problems.

2.1 R&D expenditure and firm value

In recent years, many scholars have discussed the impact of firm R&D plans on firm value (measured by firm stock price return). Hirschey and Weygandt (1985) explored the impact of R&D expenditure and advertising costs on firm stock price. The results indicated that R&D expenditure and advertising costs have significant positive impacts on firm book value and book-to-market ratio. In addition, these inputs can increase firm market value as firm durable goods. However, the period of benefits created by advertising costs is shorter and that created by R&D expenditure is longer.

Bublitz and Ettredge (1986) further used the cumulative abnormal return to analyze the impact of non-expected R&D and advertising costs on stock return, and they referred to the Lipe's (1986) model for discussion. The results show that R&D activities can indeed exert a positive impact on firm value and that firm investment in R&D activities should be reasonably evaluated by the market and in the same manner as general investment projects. Chan et al. (1990) examined the impact of the announcement of R&D expenditure on firm stock price.

They adopted the sample period from 1979 to 1985 to distinguish between two subsamples: high-tech and low-tech. They found that the stock price does have significant excess return after the announcement of R&D expenditure but that the market gives positive evaluation on the announcements made by high-tech firms. On the contrary, for firms with a lower degree of technology, the market gives significantly negative market returns, indicating that R&D expenditure can still receive positive evaluation from the capital market although it would reduce annual surplus and that industrial category has a decisive influence on the information effect of R&D expenditure. Kothari and Zimmerman (1995) also examined the relationship between R&D expenditure and firm share price. The results also pointed out that a firm's increased R&D expenditure brings about positive returns to the firm's share price, and therefore, R&D activities indeed helps to create future earnings and cash flow and further increase firm value.

Sougiannis (1994) found that R&D investment has a significant positive deferral effect on firm stock price and earnings. On average, a 1-dollar increase in R&D expenditure leads to a 2-dollar increase in profit over a 7-year period and an increase in stock value over a 5-year period. Lev and Sougiannis (1996) found that R&D expenditure not only contributes positively to firm current stock returns but also to firm future stock returns, i.e., R&D expenditure has deferred benefit to surplus. Deeds (2000) indicated that the intensity of R&D is significantly positively correlated with market added value.

From the perspective of firm business performance, Bourgeois (1981), Singh (1986), and Chakrarthy (1986) advocated that better business performance results in more resources in excess of what is required for the "normal" efficient operation of a firm and that these excess resources encourage firms to more actively interact with or compete against the environment. This means that better performance give a firm more resources to try to develop innovative products. Morbey and Reithner (1990) identified that R&D expenditure brings about net growth in firm future operating income. Dugal and Morbey (1995) also found that in the recession period where the economic environment faces a decline in the gross growth rate of real national production, a firm's sales would not decline if its R&D expenditure exceeded 3% of its sales volume, and the R&D density is significantly positively correlated with corporate profits.

In Taiwan, Lin's (2001) empirical research pointed out that the domestic capital market does have a positive evaluation of firm R&D expenditure and that firm R&D expenditure could contribute about 0.089 to 1.144 yuan for its current share price returns; Hsu (2002) pointed out that for electronic firms listed on the domestic market, there was a significantly positive relationship between the first and second phases of R&D density and shareholder returns. A 1% increase in R&D density leads to a 1.995% increase in current shareholder returns. Therefore, firm investment in R&D activities seems to focus more on the short-term. Jhao (2002) analysed the relationship between firm R&D expenditure and stock price returns after the R&D expenditure is capitalized. The results show that after capitalization, the book value of R&D assets has positive explanatory power on stock price. After dividing the sample, there are significantly positive differences between firms with higher R&D concentration and those with lower R&D concentration in terms of long-term shareholder returns. However, as for

advertising expenses with the same nature as R&D expenditure, after being capitalized, they are not positively evaluated by the stock market. Therefore, it is more appropriate to recognize the current advertising expenses.

From the perspective of firm business performance, the empirical research by Huang (1999) found that the R&D expenditure of the domestic electronics industry has a significantly negative relationship with the current revenue growth rate and that the next year's revenue growth rate has a significantly positive deferral effect; in addition, as for the relationship between R&D expenditure and firm return on assets, there is a significantly negative correlation between R&D expenditure and the current asset return rate, and there is a significantly positive deferral effect on the asset return rate in the lagged period of the previous 5 years. However, in terms of the correlation between R&D expenditure and post-tax net return, the result shows a significantly negative correlation in the current period and a significantly positive deferral effect in the lagged period of the previous 5 years. Both Ou (1998) and Yang (2002) found that R&D activities have significantly positive effects on firm operating performance and operating gross margins, respectively, in the current and the next year. Lin (2002) explored the contribution of Taiwan's listed information and electronics industry to firm value and found that R&D expenditure is significantly negatively correlated with business performance in the current year and significantly positively correlated with business performance in the next year and that there is a significantly negative deferral effect on the business performance after 4 years' lagged period. Firms with high R&D expenditure obviously have better business performance than those with low R&D expenditure, particularly in the fourth and fifth year after R&D investment.

2.2 R&D expenditure and information asymmetry

Aboody and Lev (2000) studied firm insider gains and believed that the information asymmetry caused by R&D expenditure is triggered by a firm's own investment strategy. The reason for the degree of information asymmetry caused by R&D expenditure being much greater than that caused by other tangible assets lies in the uniqueness of R&D activities. Therefore, investors cannot infer firm R&D performance by the performance of other firms' R&D activities. Another reason is that the accounting measure used in R&D expenditure is different from that used in general tangible assets. As R&D expenditure is categorized as expenses according to the current regulations, accounting statements cannot provide useful information on account of the confidentiality of information on R&D expenditures. The research results show that insiders of firms with higher R&D density earn more profits than do those of firms with lower R&D density. In addition, as most R&D projects are firm internal confidential plans and as there is no market for R&D project trading, the current market has not effectively estimated or evaluated R&D projects.

Referring to the characteristics of intangible assets, with the accounting system not yet having capitalized R&D expenditure, firms categorize current R&D expenditures as current expenses. Such an accounting system seriously underestimates firm assets. Chan, Lakonishok, and Sougiannis (2001) found that because the accounting system cannot estimate the value of

intangible assets, investors with knowledge of the accounting statements may make invalid judgments on firm stock price and future growth opportunities.

It can be seen that when firms engage in R&D activities, there will likely be information asymmetry between insiders and investors, explaining why many scholars explore the relationship between R&D expenditure and information asymmetry. Alam and Walton (1995) divided the sample into two categories: high R&D density and low R&D density. The event study method was used to analyse the stock price effect of the two subsamples after the announcement of new bond issuance. The results show that the information asymmetry caused by R&D expenditure leads to significantly positive abnormal returns when a firm declares bond issuance. That is to say, firms with high R&D density and low R&D density have significant differences in returns after the announcement. Boone and Raman (2001) used the amount of R&D expenditure as the substitute variable for information asymmetry to verify the relationship between information asymmetry and firm stock liquidity. Glosten and Milgrom (1985) mentioned that the market lose confidence in firms with serious problems of information asymmetry. Therefore, market makers suffer losses when dealing with information owners, and they increase the bid-ask spread in the market to obtain compensation from the traders who lack information. However, such increased bid-ask spreads make firms with the problem of information asymmetry left with lower stock liquidity. The empirical results of Boone and Raman (2001) are also in line with Glosten and Milgrom's (1985) inference, which confirms that firms that invest heavily in R&D activities do have relatively poor liquidity. In summary, the information asymmetry generated by firms with higher R&D expenditure is significantly different from that generated by those with lower R&D expenditure, in terms of performance on the capital market (stock performance).

In Taiwan research on the relationship between R&D expenditure and information asymmetry are rare. The empirical research by Liu (2001) found that the R&D expenditure of domestic listed firms tends to defer the financial benefits that should be obtained by the firm and that it will take 2–5 years for the benefits to show significant effects. The results show that the higher the R&D expenditure, the more obvious it is that R&D expenditure efficiency is behind the current period. Lee (2003) explored patent rights, the intangible asset closely related to R&D expenditure, to discuss whether the insiders of Taiwan-listed firms have more information than outsiders through their positions. The results show that the insiders of firms with patent rights have higher stock returns than those of patent-free firms, revealing that intangible assets do generate information asymmetry between insiders and outside investors, which, in turn, affects firm stock returns.

2.3 R&D expenditure and agency problem

Morris et al. (1991) proposed that firm R&D plans face two types of risks: uncertain future growth space and uncertain future cash income. The findings of their study also highlight the difficulty of decision-making of R&D expenditure within an enterprise. Even if firm assessment of the investment in R&D activities is of great help to its future economic benefits, there are hidden risks behind the R&D plan. If the plan fails, the huge expenses in the plan would cause great loss to the firm's surplus. Such loss would be a dilemma to be faced by firm

managers and shareholders. For example, Jensen (1993) found that most R&D plans failed to benefit as expected. But investors' high expectations of profit brought about by the R&D activities may result in overestimated stock price. In addition, when a firm invests in R&D funds, it can increase firm value. However, in the accounting statements, when the expensed annual R&D expenditure (included in the income statement under the subject of the profit and loss account) fails to consider the economic added value brought about by R&D activities, it may lead to underestimated firm value in the accounting surplus. Hall (1993) proposed that as it takes a relatively long period of time for the benefits of an R&D plan to create returns, firms expect to recover about 20%~30% of the annual profit from R&D activities, and that there are significant differences among different industries. Porter (1993) also found similar results. Nevertheless, Kothari, Laguerre, and Leone (2002) found that R&D expenditure has three times the impact on the firm future earnings variable than do general fixed assets. Chan et al. (2001) further found that the R&D density has a considerable correlation with the variation in firm stock returns. Therefore, when investors face the current distorted accounting statements as a reference for investment decisions, along with the unclear impact of the R&D activities on firm future performance, it may prompt the capital market to ignore the firm's future firm value and become short-sighted. Such a short-sighted capital market can lead to agency problems between managers and shareholders.

The results of Baber et al. (1991) indicated that when a firm's R&D expenditure affects the positive or negative value of a firm's current earnings or switches the firm's revenue from increase to decline, the firm's managers significantly reduce the firm's R&D expenditure, to maintain a relatively high level of surplus. The empirical research also found that as firm performance affects the retention of the firm's manager position, the manager has a strong motivation to conceal poor firm performance to ensure their position (Dechow and Sloan,1991; Murphy and Zimmerman, 1993). However, reducing the current R&D expenditure or other long-term expenditures to improve the firm's short-term performance is a commonly used method. Still the move is bound to be inconsistent with those shareholders whose goal is to pursue the firm's long-term interests, resulting in agency costs between the shareholders and the manager.

On the other hand, previous scholars have found that when firms invest in R&D activities, managers are given an opportunity to transfer wealth to shareholders. When a firm invests or spends money in R&D activities, there is a large demand for capital. Jensen and Meckling (1976) and Galai and Masulis (1976) found that when investment causes a firm to raise external debts, it will increase the firm's agency cost. Since investment activities such as R&D are risky, the increased risk of a firm helps to lift shareholder value when the debts are repaid within a limited period of time. However, when compared with the creditor, the shareholders must bear the risk of wealth transfer, and therefore emerges the phenomenon of redistribution of wealth. Thus, the creditor requires higher interest rates or they add more restrictions to hedge against the risk, and the increased need of capital brought about by the R&D expenditure will also result in an increase in agency costs between shareholders and creditors.

3. Research Method

3.1 Sample and data source

In the previous literature on R&D expenditure, the difficulty of obtaining data meant that the one-year cross-sectional data of specific industries were mostly taken as the object of research. To obtain a more in-depth and comprehensive understanding of the R&D activities in various industries and eras, this study takes all the firms listed on the Taiwan stock market from 1986 to 2013 as research objects. In addition, because of different industrial characteristics, relevant industries such as financial, insurance, and securities are excluded, and special stocks and beneficiary certificates are also deducted. The final sample totaled 29026 observations. This study is aimed at the annual data. The information on firm rate of return is taken from the stock price database in the Taiwan Economic Journal (TEJ), and the relevant financial information is derived from the financial database of listed firms in the general industry of the TEJ.

3.2 Variable Definitions

According to the literature review of Fong, Tseng, Chung, and Shen (2000), the factors that affect the R&D expenditure of enterprises at home and abroad can be roughly divided into two categories: industrial and environmental characteristics and enterprise characteristics. However, the main purpose of this study is to explore how firms balance the growth benefits brought about by R&D expenditure on one side and the information asymmetry and agency problems also brought about by R&D expenditure on the other side, to obtain the optimal level of R&D expenditure. We use the method of ordinary least square (OLS) (Note 1) of pooled cross-sectional data to estimate multiple regression analysis and list the definitions and operations of the variables in the model as follows:

$$RDRATE_{i,t} = \alpha_0 + \alpha_1 FCF_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 LNRET_{i,t} + \alpha_4 OPP_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 FINL_{i,t} + \varepsilon_{i,t} \quad (1)$$

3.2.1 Dependent variable

RDRATE: Research and development ratio. Because the absolute amount of R&D expenditure does not eliminate the effect of firm size and because it is prone to heteroscedasticity (Hoskisson and Hitt, 1988), we adopt the methods of Hambrick and McMillan (1985) and Baysinger and Hoskisson (1989) and use the ratio of R&D expenditure as a measure to eliminate scale effects and to reduce the possibility of heteroscedasticity.

$$RDRATE = \frac{R\ \&\ D\ \text{expenditure}}{\text{Net sales}} \times 100\% \quad (2)$$

3.2.2 Explanatory variables

FCF: Free cash flow, a substitute variable for equity agency costs (Jensen, 1986). It equals operating profit before depreciation - interest expense - income tax expense - cash dividend.

SIZE: Firm size, a substitute variable for information asymmetry (Hasbrouck, 1991). Because of the small number of shares in circulation, the internal shareholding ratio in small firms is

relatively high. There are relatively more incentives for insiders to conceal the hidden key information in pursuit of private gains, leading to more serious information asymmetry. This study uses firm market value as a variable to measure firm size.

LNRET: This measures firm value. This study uses the stock price return rate as a reference indicator for firms to make the optimal R&D expenditure decision. It takes the adjusted stock price return rate from the Taiwan Economic Journal, and natural logarithm (Ln), in response to the concept of using continuously compounded interest to calculate returns, to preserve the additive nature of time series.

OPP: This means a firm's future investment growth opportunities. Because a firm's future investment opportunities are critical to its investment decisions, firm current market to book ratio is taken as the substitute variable for investment opportunity （Myers, 1977）.

$$OPP=\frac{M}{B}=\frac{\text{Bookvalueof totalassets- bookvalueof totalequities+ marketvalueof totalequities}}{\text{Bookvalueof totalassets}} \quad (3)$$

3.2.3 Control variables

ROA: This measures firm performance. As return on assets (ROA) is an effective indicator that is used to measure firm business performance (Lant, Milliken, and Batra, 1992； Trevino and Daniels, 1994, 1996), ROA is adopted in this study as a reference indicator for firms to make optimal R&D expenditure decisions.

$$ROA=\frac{\text{Net income before interest and tax}}{\text{Total assets}}\times 100\% \quad (4)$$

FINL: This means debt ratio. This study adopts the debt ratio measured by previous related research (Hitt et.al,1991) as the control variable.

$$FINL=\frac{\text{Total liabilities}}{\text{Total shareholder's equity}}\times 100\% \quad (5)$$

4. Results of Empirical Analysis

The purpose of this study is to observe the decision-making behaviour of listed firms in R&D expenditure. Because of the difficulties in making the decisions of R&D expenditure, firms need to make a trade-off between firm future competitive potential and current surplus, as well as the possible subsequent agency problem and information asymmetry. Thus, the data collected in this study includes all the listed firms from 1986 to 2013 as the sample group, and industries such as financial, insurance, and securities are excluded to avoid bias. In addition, in accordance with Fong et al. (2000), who discovered the impact of industry, environment, and corporate characteristics on firm R&D expenditure, this study explores different overall economic conditions (including monitoring indicator, leading indicator, real GDP growth, and different eras) and industrial characteristics (including listed firms and electronic and non-electronic stocks), in the hope that we can use the subsamples to explore the differences in

decision-making on R&D expenditure under different contexts. The empirical results at various stages are shown as follows.

4.1 Entire sample

First, the basic descriptive statistics of each variable and the results of the Spearman's rho correlation coefficient matrix used for the preliminary observation of the degree and direction of the correlation between the variables are disclosed in Tables 1 and 2, respectively. Table 3 shows the empirical results of the decision-making on R&D expenditure using the entire sample. In the Spearman's rho correlation coefficient matrix in Table 2, although the Spearman's rho correlation coefficients of most variables are significantly different than 0, the results of the collinearity statistics in Table 3 show no significant collinearity problems for the variables in the model. The main empirical results in Table 3 indicate that the free cash flow (FCF) used to measure agency problems is not statistically significant but that it indeed shows a negative coefficient of -0.10, which means that firms with more FCF may have more agency problems, which do have a negative impact on RDRATE. In addition, we try to verify information asymmetry through firm size (SIZE). Just as the past literature found that the smaller the firm size the more serious the information asymmetry, we also found no significantly positive relationship between SIZE and RDRATE, which also shows that although the statistical relationship is not significant, larger firm size reduces information asymmetry problems and further improves R&D expenditure.

Table 1. Descriptive statistics

	Min. value	Max. value	Average	Standard deviation
RDRATE	.0000	157018.7500	20.227874	1.3414731E3
FCF	-421877648	401185110	315215.06	9271846.870
SIZE	31	2735469	15549.60	70514.353
LNRET	-290	339	3.05	54.931
OPP	.00	2.44	.3935	.18862
ROA	-8.81	1.10	.0562	.13664
FINL	-992.73	913.33	1.3958	9.81474

Note 1: RDRATE: R&D expenditure ratio; FCF: free cash flow; SIZE: firm size LNRET: ln (return on share price); OPP: future investment growth opportunity; ROA: return on assets; FINL: debt-to-equity ratio.

Table 2. Spearman's rho correlation matrix

	RDRATE	FCF	SIZE	LNRET	OPP	ROA	FINL
RDRATE	1.000	-.012	-.039**	-.029**	-.261**	.010	-.287**
FCF	-.012	1.000	.299**	.019*	-.153*	.245***	-.176**
SIZE	-.039**	.299**	1.000	.242**	-.025**	.370**	-.026**
LNRET	-.029**	.019*	.242**	1.000	-.043**	.300**	-.045**
OPP	.010	.245**	.370**	.300**	1.000-	.271**	-.180**
ROA	-.261**	-.153**	-.025**	-.043**	-.271	1.000**	.999**
FINL	-.287**	-.176**	-.026**	-.045**	.999**	-.180**	1.000

Note 1: RDRATE: R&D expenditure ratio; FCF: free cash flow; SIZE: firm size; LNRET: ln (return on share price); OPP: future investment growth opportunity; ROA: return on assets; FINL: debt-to-equity ratio.
Note 2: ** represents the statistical significance level of two-paired test of 1%.
Note 3: * represents the statistical significance level of two-paired test of 5%.

Table 3. Research and development expenditure decision model for the entire sample

Model	Standardized Coefficients	Sig.	Collinearity Statistics	
			Tolerance	VIF
(Constant)		.000		
FCF	-.010	.321	.593	1.686
SIZE	.006	.511	.593	1.685
LNRET	.006	.413	.933	1.072
OPP	-.134***	.000	.840	1.191
ROA	-.096***	.000	.886	1.129
FINL	.020**	.014	.871	1.147

Note 1: The study adopts the method of ordinary least square (OLS) of pooled cross-sectional data to estimate the multiple regression analysis.

$$RDRATE_{i,t} = \alpha_0 + \alpha_1 FCF_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 LNRET_{i,t} + \alpha_4 OPP_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 FINL_{i,t} + \varepsilon_{i,t}$$

Note 2: RDRATE: R&D expenditure ratio; FCF: free cash flow; SIZE: firm size;NRET: ln (return on share price); OPP: future investment growth opportunity;ROA: return on assets; FINL: debt-to-equity ratio
Note 3: *** represents the statistical significance level of two-paired test of 1%
Note 4: ** represents the statistical significance level of two-paired test of 5%

Although the results of all the samples in this study find that the impact of agency problems and information asymmetry on company R&D investment is not statistically significant and that the direction of the regression coefficient is the same as that expected by us. In addition, in terms of other explanatory variables, the impact of LNRET on RDRATE is positive, 0.006.

Although it does not reach the statistically significant level, it can be inferred that the decision-making of firm R&D expenditure is indeed influenced by investors' positive affirmation of firm value. In addition, firm investment growth opportunity (OPP) also has a significant negative relationship with RDRATE, with an estimated coefficient of -0.134. Although this result differs from that in which firms make more optimistic and positive R&D investment under expectant future growth opportunities, it reveals that firms are willing to be more cautious regarding innovative R&D challenges in the anticipation of an optimistic future. In terms of control variables, there is a significantly negative coefficient of -0.096 between firm ROA and RDRATE, which is in line with our expectations. It indicates that R&D expenditure must be recognized as current expense in the accounting system, thus affecting the current surplus and reducing the level of asset returns. In terms of the control variable FINL, a significant coefficient +0.020 indicates that firm R&D expenditure indeed affects its capital structure.

4.2 Re-examination of R&D expenditure decisions under different overall environments

To determine whether the differences in the overall environment exert different impacts on firm R&D expenditure decisions, we further re-observed the entire sample on the basis of different monitoring indicators and different eras. The data in Table 4 show the changes in firm decision-making behaviour on R&D expenditure under different monitoring indicators. In what is case with the entire sample, both ROA and OPP have a significant negative relationship with RDRATE regardless of the overall annual economic situation. This once again illustrates the dilution effect of R&D expenditure on earnings and the cautious R&D expenditure decision made by firms in the presence of a high potential for future growth. However, interestingly, FINL shows a statistically insignificant positive relationship when the monitoring indicator shows a green light and a yellow and red light. Unlike the previous findings from the entire sample, it seems that firm capital structure does not significantly affect firm R&D decision-making in a relatively optimistic economy. However, when the indicator shows that the economy falls into recession, which is denoted by a blue light or a yellow and blue light, firm R&D decision-making is affected by firm capital structure.

Table 4. R&D expenditure behavior of firms in different overall environments and eras with different levels of R&D intensity

Model	Standardized Coefficients						
	Monitoring Indicator (Light Signal)				Period		
	Blue (Sluggish)	Yellow-Blue (Transitional)	Green (Stable)	Yellow-Red (Transitional)	1986~2000	2001~2011	2012~2013
(Constant)							
FCF	-.004	-.019	-.009	-.013	-.072***	-.006	-.017
SIZE	.004	.004	.008	.015	.111***	.005	.008
LNRET	.022	.049*	.005	-.014	-.043**	.002	.003
OPP	-.143***	-.211***	-.126***	-.163***	-.135***	-.152***	-.153***
ROA	-.100***	-.093***	-.101***	-.138***	.025	-.126***	-.053***
FINL	.033**	.074**	.017	.016	.004	.023**	.046**

Note 1: The study adopts the method of ordinary least square (OLS) of pooled cross-sectional data to estimate the multiple regression analysis.

$$RDRATE_{i,t} = \alpha_0 + \alpha_1 FCF_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 LNRET_{i,t} + \alpha_4 OPP_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 FINL_{i,t} + \varepsilon_{i,t}$$

Note 2: RDRATE: R&D expenditure ratio; FCF: free cash flow; SIZE: firm size; LNRET: ln (return on share price); OPP: future investment growth opportunity; ROA: return on assets; FINL: Debt-to-equity ratio.

Note 3: To avoid subjectively distinguishing different subsamples of the overall economic situations, this study takes the monitoring indicators of each year as the indicator for overall economic situations. The monitoring indicator is the sum of the indicator scores of nine economic activities published monthly by the Council for Economic Planning and Development, Executive Yuan, namely monetary aggregate M1B; direct and indirect finance; TAIEX average closing price; industrial production index; non-agricultural employment; customs export value; imports of machineries & electrical equipment; TIER manufacturing composite indicator/index of producer's shipment for manufacturing; and sales of trade and food services. The highest score for the monitoring indicator is 45, and the lowest is 9. The comprehensive scores obtained are used to distinguish the corresponding monitoring indicators for them to be used as a reference for future monitoring. The scores and meaning of each monitoring indicator are shown as follows: If the comprehensive indicator score falls between 9 and 16, it shows a blue light, meaning that the economy is in a downturn; a score between 17 and 22 shows a yellow-blue light, meaning that the economy is getting rid of a downturn; a score between 23 and 31 shows a green light, meaning that the economy is stable; a score between 32 and 37 shows a yellow-red light, meaning that the economy is growing steadily;

and a score between 38 and 45 shows a red light, meaning that the economy is booming. There was no indicator flashing a red light in the samples during the 28-year study period.

Note 4: According to the statistics from the Indicators of Science and Technology of the Republic of China issued by the Ministry of Science and Technology, the proportion of Taiwan's overall R&D expenditure to GDP has increased year by year ever since it exceeded 2% in 2001, and it has increased to more than 3.1% since 2012. Thus, this study has divided the entire sample period into three parts, which are the low R&D era before 2000, the leap forward R&D era from 2001 to 2011, and the high R&D era after 2012.

Note 5: *** represents the statistical significance level of two-paired test of 1%.

Note 6: ** represents the statistical significance level of two-paired test of 5%.

Note 7: * represents the statistical significance level of two-paired test of 10%.

In addition, as the proportion of Taiwan's overall R&D expenditure in GDP has exceeded 2% and increased gradually since 2001 and has exceeded 3.1% since 2012, this study has divided the entire sample period into three parts, which are the low R&D era before 2000; the leap forward R&D era from 2001 to 2011; and the high R&D era after 2012. The right-hand side half of Table 4 shows the results under different eras with different R&D intensities. The R&D expenditure decisions after 2000 show the same result as that shown by the entire sample; however, before the low R&D era preceding 2000 firms made very cautious decisions on R&D expenditures. FCF, SIZE, and LNRET are all key factors that significantly affect firm behaviour, indicating that in the early days, of low R&D density, agency problems and information asymmetry significantly affected firm R&D expenditure decisions. We believe that a smaller agency problem (less FCF) leads to less asymmetric information (larger SIZE), as well as the lowest return on stock price, all of which prompt a firm to conduct more active R&D actions.

4.3 Re-examination of R&D expenditure decisions under different industrial characteristics

In addition to the overall environmental factor affecting firm decision-making, this study carries out discussions by further dividing the samples into two subsamples, which are listed firms and OTC firms, and into two other subsamples, which are electronic stocks and non-electronic stocks. The results in Table 5 indicate that in what is different from the entire sample and listed firms, OTC firms have smaller agency problems and larger firm size, which can encourage them to have more active R&D expenditure activities. As for the subsamples of electronic stocks and non-electronic stocks, different returns on stock price lead to different directions of decision-making. For general industry firms with non-electronic stocks, R&D expenditure decisions are all significantly subject to positive feedback from investors. However, as for firms with electronic stocks, R&D expenditure plays a more important role in the electronics industry because of fierce competition in the industry. Thus, when the stock price returns are low, firms are motivated to conduct more R&D expenditure.

Table 5. R&D expenditure behavior of firms in different market categories and industries

Model	Standardized Coefficients			
	Market level		Industry level	
	TWSE	GTME	Electronics	Non-Electronics
(Constant)				
FCF	-.014	-.031**	-.027	-.011
SIZE	.018	.060***	.021	.002
LNRET	-.002	.006	-.031**	.021**
OPP	-.128***	-.160***	-.286***	-.133***
ROA	-.066***	-.123***	-.194***	-.109***
FINL	.017*	.028*	.073***	.016*

Note 1: The study adopts the method of ordinary least square (OLS) of pooled cross-sectional data to estimate the multiple regression analysis.

$$RDRATE_{i,t} = \alpha_0 + \alpha_1 FCF_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 LNRET_{i,t} + \alpha_4 OPP_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 FINL_{i,t} + \varepsilon_{i,t}$$

Note 2: RDRATE: R&D expenditure ratio; FCF: free cash flow; SIZE: firm size; LNRET: ln (return on share price); OPP: future investment growth opportunity; ROA: return on assets; FINL: debt-to-equity ratio.

Note 3: *** represents the statistical significance level of two-paired test of 1%.

Note 4: ** represents the statistical significance level of two-paired test of 5%.

Note 5: * represents the statistical significance level of two-paired test of 10%.

5. Conclusions and Suggestions

This study examines the decision-making on optimal R&D expenditure for listed firms in Taiwan during the period1986 to 2013.The results of the empirical analysis are summarized as follows:

A significant negative correlation between the rate of return on assets and the ratio of R&D expenditure can be observed in both the entire sample group and different subsample groups. This again demonstrates the problem that the loss of book value and negative dilution might appear in current surplus if R&D expenditure is recognized in the accounting system as expenses. This may cause firms to be affected by pressure from the current target surplus level when making R&D expenditure decisions, resulting in the failure to grasp the innovation opportunities in time. Therefore, in addition to the disclosure of intangible assets such as patents in the notes to the financial statements, the development of a set of appropriate accounting methods proposed by many research institutes to capitalize intangible assets such as R&D investment is worthy of further improvement by relevant units. The significantly negative relationship with future investment growth opportunities indicates that firms are optimistic regarding future investment growth opportunities but hold a more cautious attitude

and that investors show positive support for firm investment in R&D activities. These results further motivate firm management to invest in innovative activities with more confidence and incentives. This is because firms need the recognition and support of shareholders before making active progress in R&D innovation. Thus, when making R&D expenditure decisions, firms should cautiously assess future growth opportunities so as to seize the opportunity to help raise their future competitiveness and firm value.

Although the agency problems and the information asymmetry possibly brought up by R&D expenditure, is not statistically significant in the empirical results of the entire sample, the empirical results show that these negative effects may indeed make firms pay a higher price while pursuing firm value increase.

Acknowledgments: The authors thank Crimson Interactive Pvt. Ltd. (Ulatus) – www.ulatus.tw for their assistance in manuscript translation and editing.

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

Notes

Note 1. Since the research data also complies with the characteristics of the Panel Data, we refer to the opinions given by an anonymous reviewer and adopt the Generalized Method of Moments (GMM) for analysis. As the direction and significance of the coefficient in the empirical results are similar to those of the coefficient derived through the method of OLS adopted in this study, the empirical results are still presented by using the OLS method.

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