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R&D 增加及資本結構對長期異常報酬的影響：
台灣案例

The Effect of R&D Increases and Capital Structure on Long-Term
Abnormal Stock Returns: The Case of Taiwan

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R&D 增加及資本結構對長期股票異常報酬率的影響：台灣案例

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摘要

本文章主要目的為探討 R&D 增加的公司其資本結構對長期異常報酬的影響。樣本為民國八十年九月到民國八十九年六月 R&D 增加的公司，利用 Fama and French (1993, 1996) 三因子模型檢驗其 R&D 增加後五年的長期異常報酬表現(民國八十年九月到民國九十四年五月)，同時比較電子業、非電子業，高負債公司、低負債公司其長期異常報酬的差異性。實證結果發現台灣電子業在 R&D 投資表現比非電子業好，R&D 增加伴隨高負債比低負債的長期異常報酬高。尤其是在電子業中，R&D 增加且高負債的公司有顯著及正向的長期異常報酬，此結果符合負債監督假說及代理成本之資本結構模型。我們支持投資者可以觀察公司其負債高低來預測市場對其 R&D 的反應。

關鍵字：研發、異常報酬、槓桿度、電子業、非電子業、三因子模型。

The Effect of R&D Increases and Capital Structure on Long-Term Abnormal Stock Returns: The Case of Taiwan

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ABSTRACT

This paper investigates the effect of leverage on abnormal stock returns following increases in R&D in Taiwan. The abnormal returns are measured over 60 months (5 years) following the increases in R&D for 645 firms listed on the TSE from September 1991 through June 2000 using the Fama and French three-factor model. Furthermore, the sample is also partitioned into high-leverage and low-leverage firms, electronics and non-electronics industries to investigate the difference. Corresponding to the debt monitoring hypothesis and the agency cost of the capital structure model, the empirical results show that the long-term performances of the R&D investment of firms in Taiwan's electronics industry are better than those of firms in the non-electronics industry and the high-leverage firms with increases in R&D have higher abnormal returns than low-leverage ones. In the electronics industry, the high-leverage firms have higher positive abnormal returns. Thus, we infer that investors can observe the leverage level of firms in order to predict how the market reacts to the quality of R&D.

Key words: R&D; Abnormal Return; Leverage; Electronics Firms; Three Factor Model.

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The Effect of R&D Increases and Capital Structure on Long-Term Abnormal Stock Returns: The Case of Taiwan

1. Introduction

Research and development (R&D) is one type of intangible asset of firms that can generate new ideas as well as information and knowledge, and so companies with strong R&D ability may have a competitive advantage over others without such ability. The growth of the technology sector over the last few decades and the corresponding increase in research and development spending has raised the question of whether stock prices reflect the information pertaining to research and development activities. For Taiwan, a dynamic economy encounters rapid changes in industry at the global level, thus innovation is the key to enhancing its industrial competitiveness, and to simulating its overall economic growth. As R&D is the source of innovation, R&D has without a doubt currently become the most important emphasis in the world's leading countries. Taiwan has generally concentrated its efforts on specific industries and it has rapidly changed the objects of its focus. For instance, the industries in which Taiwan has been competitive have ranged from umbrellas and shoes during the early period of its economic development to computers and semiconductors in more recent years. However, Taiwan has often suffered from a lack of R&D activity that has been geared towards original, pioneering, and self-contained technologies. While Taiwan's industries have played the most important role in its system of innovation, not only in terms of R&D implementation, but also in R&D financing, the government has been the second largest source of R&D funding in Taiwan, and has provided most of the funding for R&D activities in universities and research institutes.

R&D spending in industries continues to increase year by year in Taiwan. For example, according to a report published by the National Science Council on science and technology indicators Taiwan, business R&D intensity (R&D expenditure as a percentage of value-added in industry) in 1999 and 2004 amounted to 1.65% and 2.11 %, reflecting an increase of 0.46 percentage points over 5 years. When compared with the business R&D intensity of 3.13% recorded in Japan, followed by the percentage of 2.99% recorded in South Korea, the business R&D intensity in Taiwan in 2004 was a little lower. In addition, the R&D expenditure of the manufacturing sector in countries mainly focusing on the manufacture of hi-tech products, such as Taiwan, Finland, South Korea and Ireland, exhibit high R&D percentages in the hi-tech industry. Germany, Australia and Italy mainly concentrate on medium hi-tech industries. From the above, it can be seen that the most important aspect in terms of the economic growth in Taiwan has been the growth of electronic technology which is highly dependent upon R&D.

The technology-oriented companies in all kinds of industries raise the question whether their stock market values reflect their intangible R&D capital. Unfortunately, accounting measurement and reporting rules treat R&D differently from other investments. While the quarterly and annual reports of most financial investments and physical assets provide investors with updated information regarding changes in asset values, no information on value and productivity changes in R&D is reported to investors. Thus, R&D gives rise to substantial information asymmetry between managers and investors (e.g., Abooy and Lev, 2000).

The cost of an increase in R&D that is considered to be an expense is clearly tangible. By contrast, the potential benefit of an R&D increase reflects intangible information regarding future cash flows and the valuation problem may be especially challenging. Daniel and Titman (2001) report that investors misreact to intangible information but not to tangible information. In this sense, R&D increases can test the ability of the market to correctly incorporate the intangible benefit of a long-term investment. If investors misreact to the intangible information of firms' R&D increases, then significant long-term abnormal stock returns can be observed following such increases. Other studies show the long-term abnormal stock returns following corporate events such as seasoned equity offerings and stock repurchases (e.g., Eberhart and Siddique, 2002; Loughran and Ritter, 1995).

Moreover, the effects of the financial leverage associated with R&D investments have been the subject of numerous studies. Some studies find that abnormal stock returns at announcements of planned increases in R&D expenditure are positively related to the debt ratio (e.g., Szewczyk, et al., 1996; Zantout, 1997). Other studies observe a negative association between the debt ratio of the firms and R&D investment effect on the value of firms (e.g., Bhagat and Welch, 1995).

This paper differs from other studies in several ways. First, the long-term abnormal stock returns of firms are examined following R&D increases. Chan, Lakonishok, and Sougiannis (2001) test abnormal stock returns in relation to the R&D intensity of firms. Their findings indicate that the market correctly incorporates R&D intensity into the stock valuation. However, they do not imply that the market correctly values increases in R&D because high R&D-intensity firms may not have recently increased their R&D. Second, as to whether leverage affects abnormal stock returns following increases in R&D is an issue that needs to be explored. The test performed here is unlike those of recent studies. In a recent study, Ho, Tjahjapranata, and Yap (2006) explored the interaction effect of financial leverage and firm size on R&D investment in the growth opportunities of a firm. Nevertheless, Isberg (1996) showed that the impact of financial leverage and investment in R&D may depend on firm size, and so the effect of firm size is controlled for by using a three-factor model in this paper.

A sample of 3,390 observations is constructed where firms increase their R&D intensity (e.g., the ratio of R&D to total assets) by more than 5%. Next, the sample is divided into sub-samples, namely, high-leverage firms, low-leverage firms, electronics firms and non-electronics firms. Then, abnormal stock returns are comprehensively studied by employing Fama and French's three-factor model during the sample period (1991 to 2005). Finally, this paper examines whether leverage affects abnormal stock returns following increases in R&D.

The main contribution of this paper is that it seeks to determine whether the leverage has an effect on the abnormal stock returns following the increases in R&D in Taiwan. Furthermore, the sample in this paper is also partitioned into high-leverage and low-leverage firms, the electronics and non-electronics industries in order to investigate whether differences are found across certain groups of firms.

The remainder of this paper is organized as follows. Section 2 discusses the data as well as the sample selection procedures and presents some of the descriptive statistics. Section 3 contains our methods and Section 4 analyses our empirical results. Section 5 summarizes and concludes the paper.

2. Literature Review

Many studies have attempted to build rational asset pricing models. Reinganum (1981) argued that the cross-section of the average returns on U.S. common stocks show little relation to the market β of the Capital Asset Pricing Model described in Sharpe (1964) and Lintner (1965). Fama and French (1992a) reported joint roles of market β, size, earnings-to-price, leverage, and book-to-market equity in cross-sectional of average stock returns. Fama and French (1992b) went on to document that size and book-to-market equity are related to economic fundamentals. Later, Fama and French (1993, 1996) used excess returns on portfolios with size and book-to market equity as the dependent variables in their time-series regressions.

By employing the Fama and French three-factor model, Eberhart and Siddique (2002) analyzed the long-term abnormal returns of corporate bonds and stocks following seasoned equity offerings. They stated the significance levels of all abnormal stock and bond returns with standardized and unstandardized methods except for those for value-weighted stocks returns with unstandardized methods.[1] Eberhart, Maxwell, and Siddique (2004) also used the Fama and French three-factor model and the Carhart four-factor model by adding a momentum factor to find the long-term abnormal returns following R&D increases. The long-term abnormal returns were both found to be significantly positive.

The relationship between financing and investment has been discussed in past studies. For instance, Modigliani and Miller (1958) argued that the financing and investment decisions are separate processes. In other words, when the condition was given certain simplifying assumptions – no tax, no transaction costs and so on, the value of a firm was independent of its capital structure. Nevertheless, Jensen and Meckling (1986) argued that the potential interaction was between the investment and financing decisions. Some authors seemed to support this point of view; for instance, by relaxing the assumption of a tax-free world, Modigliani and Miller (1963) stated that the value of the firm increased with leverage because of the tax deductibility of the interest payment. In addition, Jensen (1986) noted that debt that reduced the free cash flow available to managers could go against managerial discretion. Hence, the potential agency and tax benefit of debt may exert a positive influence on the investment of firms. In recent studies, Szewczyk, et al. (1996) found that R&D-induced abnormal returns were positively related to the percentage increase in R&D spending, the debt ratio and institutional relationships, and Zantout (1997) pointed out that abnormal stock returns upon announcements of planned R&D expenditure increases were positively related to the debt ratio. Ho, Tjahjapranata, and Yap (2006) showed that nonsignificantly ambiguous results were found for the independent effect of financial leverage on R&D investment in generating growth opportunities.

[1] The returns and risk factor were standardized each month by the cross-sectional standard deviation of all the returns in the portfolio each month and the standard errors of unstandardized returns were corrected for heteroskedasticity and autocorrelation.

According to Jensen and Meckling (1976), agency costs were associated with debt. Agency cost problems occurred when the interests of the debt holders (principal) and managers (agent) could not be aligned in an R&D investment which resulted in underinvestment. Hence, debt holders would demand a premium that raised the cost of the debt, and the value of the investment would be reduced. In addition to agency cost problems, information asymmetries also reduced the attractiveness of the investments. Outside investors (debt holders) might have overestimated the investment risk when managers raised the level of leverage; in fact, managers might have withheld information to maintain confidentiality for competitive reasons. Bhagat and Welch (1995) observed a negative association between the debt ratio of firms and the R&D investment effect on the value of those firms. Myers and Majluf (1984) presented a "pecking order" model to explain corporate financing decisions and noted that managers used excess cash flows to pay off debt when the profitability of the investment was high; conversely, the firm borrowed money to fund investment when the profitability of the investment was low, so that the debt level might have gone up.

As to whether the abnormal return differs among the different categories of firms has been a focus of many authors. For instance, Chan, Martin, and Kensinger (1990) suggested that high-technology firms that announce increases in R&D spending experienced positive abnormal returns on average, whereas announcements by low-technology firms were associated with negative abnormal returns. Furthermore, in cross-sectional analyses, higher R&D intensity than the industry average led to larger stock-price increases only for firms in high-technology industries.

With regard to R&D innovation, Chang and Shih (2004) found that the comparison of the innovation systems of Taiwan and China revealed that each had unique structural characteristics, as well as numerous complementary features and other phenomena. Their study also suggested the possibility of future cooperation between the two sides on science and technology subjects. For instance, China is still in the catch-up stage and thus needs to import technology; however, Taiwan has successfully established several high-tech industries and developed relevant technology. Thus, Taiwan could help China develop its technologies and benefit from cooperation with China to increase the economic scale of its manufacturing capacity. Mathews (2001) stated that several alliances had been formed in Taiwan in the late 1990s through the bringing together of firms and public sector research institutes with the added organizational input of trade associations and catalytic financial assistance from the government.[2]

3. Data and Research Methodology

3.1 Data

Our sample consisted of observations with increases in R&D for 645 firms listed on Taiwan Stock Exchange (TSE) from September 1991 through June 2000. Financial firms and firms with negative book values were excluded from the sample. In addition, stock returns for all firms in the sample over 60 months (5 years) following their R&D increases needed to be available from the Taiwan Economic Journal (TEJ) database. Thus, the return series covered the period from September 1991 to May 2005. Sufficient financial data also had to be available from the TEJ database during the same period to calculate the variables used in this paper, such as market value and the book-to-market ratio, and the market index returns were provided by the Taiwan Stock Exchange (TSE).

The measures of R&D intensity differed from those in previous studies. According to Louis, Chan, and Sakonishok (2001), R&D intensity was measured as R&D expenditure relative to sales, an indicator of how many resources a firm devotes to R&D (see the Value Line Investment Survey). It was a problem, however, that R&D expenditures relative to

[2] In 1991, the power of Taiwan's public-private cooperation led the Laptop PC project to world markets, as in the case of Acer achieving global brand status.

sales seemed to be affected by dramatic variations in sales. The firms with R&D increases in our sample were selected incorrectly due to this problem, and using an incorrect sample in the tests may have wrongly affected the results. Hence, the increase in a firm's ratio of R&D to total assets is referred to as an R&D increase in this paper. This point of view is also supported by Ming and Zhang (2004) who pointed out that the ratio of R&D expenditure to total assets was relatively stable and helpful in explaining the average expected stock return. Following Eberhart, Maxwell, and Siddique (2004), when firms increased their ratios of R&D to assets by at least 5% compared to the corresponding ratios of R&D to assets in the previous period, the observations were included in the sample. The sample in this paper consisted of 3,390 observations related to increases in R&D.

This paper also discusses the long-term abnormal stock returns on the leverage levels of firms with increases in R&D in the electronics industry, and so 3,390 observations with their stock identification code were classified as electronics companies as defined by the TSE. Because R&D investments are concentrated in the electronics industry in Taiwan, this paper studies this group separately.

Based on the ratios of long-term debt to total assets at the beginning of the sampled firms' increases in R&D, the observations in the sample were separated into high-leverage or low- leverage groups. When a firm's ratio of long-term debt to total assets was above the median leverage ratio of the sampled firms, the firm belonged to the high-leverage group of firms. However, when it was below that median ratio, the firm belonged to the low-leverage group of firms. The long-term debt was used because R&D is a long-term investment that is normally financed with long-term financing. Similarly, the data on long-term debt can be obtained from the TEJ.

3.2 Variable Definitions

Several variables were used in this paper. One variable, size, referred to the market value of a firm and was calculated by the stock price timing the total number of shares outstanding. Another variable, book-to-market equity (BE/ME), was calculated by dividing the book value of equity plus deferred taxes by the market value of equity, which involved accounting- and market-based variables. The book value of equity, in turn, was the value of a company's assets expressed on its balance sheet. Besides the variables of size and book-to-market equity, the market index return was a value-weighted market index return, calculated by all currently-listed common stocks except newly-issued stocks and the stocks of financially distressed firms.

3.3 Descriptive Statistics

Descriptive statistics for the sample are shown in Tables 1 and 2. As shown in Table 1, on average, the ratio of R&D to total assets was 1.51%, the market value was 18,736 million dollars, the market-to-book equity ratio was 2.6 and the monthly return was 1.51% as of the beginning of the sample firm's R&D increase month. Compared with the 13% recorded for U.S. companies, the ratio of R&D to the total assets of the firms in Taiwan was relatively low. The distribution of all firms in this sample using the two-digit industry code based on the categories of the Taiwan Stock Exchange Corp. is provided in Table 2. The electronics industry (Industry Code 2300) with 1,437 R&D increases, as seen in Table 2, had the largest representation, followed by the electrical machinery industry (Industry Code 1500) with 316 R&D increases, the transportation sector (Industry Code 2600), the tourism industry (Industry Code 2700) and the wholesale and retail industry (Industry Code 2900) with 0 R&D increases. It is obvious from these results that firms with R&D increases were almost all concentrated in the electronics industry, constituting nearly one out of two observations because the electronics industry might have particularly needed more R&D to promote its level of technology or maintain its core competence.

3.4 Research Methodology

Many methods can be used to measure abnormal returns, such as cumulative abnormal returns, buy-and-hold abnormal returns, and calendar-time portfolios. In fact, Brav and

Gompers (1997) argued that the approach used to calculate cumulative and buy-and-hold abnormal returns with cross-sectional dependence in sample observations can lead to poorly specified test statistics in sampling situations. The calendar-time portfolio methods were found to eliminate the problem of cross-sectional dependence among sample firms because the returns of sample firms were aggregated into a single portfolio. The general approach to calendar-time portfolios was discussed by Fama (1998) and implemented in recent work by Loughran and Ritter (1995) and Brav and Gompers (1997).

By following Fama and French's methodology (p.8-p.10, 1993) very closely, this study used six portfolios to examine common risk factors in returns related to size and book-to-market equity. The portfolios were formed on a monthly basis from a simple sorting of firms into two groups based on size and three groups based on the BE/ME. First, in June of each year t from1991 to 2005, all stocks (expect financial stocks) listed on the TSE were ranked by size (price times shares). The median size was used to split all stocks in the sample into two groups, namely, small firms or big firms (S or B). Second, the stocks were also assigned to three BE/ME groups based on breakpoints for the bottom 30 percent (low, or L), the middle 40 percent (medium, or M), and the top 30 percent (high, or H) of the ranked values of the BE/ME for all stocks listed on the TSE. The ranked values of the BE/ME for all stocks listed on the TSE were measured at the end of December in year t-1 from 1991 to 2005. Thus, six portfolios (S/L, S/M, S/H, B/L, B/M, and B/H) were finally constructed from the intersection of the two sizes and three BE/ME groups and monthly equal-weighted and value-weighted returns on six portfolios were calculated from July of year t to June of year t+1.

The Fama and French three-factor model (1993, 1996) was used in this paper to test the long-term abnormal stock returns and is specified in Equation (1):

$$R_{pt} - R_{ft} = \alpha + b(R_{mt} - R_{ft}) + sSMB + hHML_t + \varepsilon_{pt}, \qquad (1)$$

where R_{pt} is the average raw return for stocks in calendar month t (where a sample stock is included if month t is within the 60-month period following its R&D increase), R_{ft} is the average of five major commercial banks' 1-month deposit rates, R_{mt} is the value-weighted market index return, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio with low book-to-market ratios. Hence, the inference was based on the t-statistic derived from the time-series of the monthly calendar-time portfolio abnormal returns. All t-statistics were adjusted for heteroskedasticity using White's (1980) method.

Previous studies have argued that although the calendar-time portfolio methods yield more robust test statistics in nonrandom samples, the calendar-time portfolio methods often yield misspecified test statistics in nonrandom samples. In addition, calendar-time abnormal returns do not precisely measure investor experiences. Value-weighted and equal-weighted calendar-time returns were both used in this paper. A debate revolves around the use of value-weighted versus equal-weighted calendar-time returns. Loughran and Ritter (2000) argued that equal weighting was better because it did not obscure the mispricing that was more likely to occur with smaller firms. On the other hand, Fama (1998) argued that value weighting was more appropriate because it more accurately gave the total wealth effects experienced by investor.

4. Empirical Results

Table 3 shows the results of Equation (1), which are the long-term abnormal returns for the full sample using the Fama and French three-factor model for the 1991 to 2005 period. The alphas, which represent the abnormal return measure, were found to be significantly positive (0.11%) with an equal-weighted measure, but to be insignificant with a value-weighted measure. The small abnormal returns for the full sample may have been due to the relatively small amounts of spending on R&D by firms in Taiwan. This result was similar to that of Eberhart, Maxwell, and Siddique (2004), who found alphas with equal-weighted and value-weighted measures of 0.69% and 0.43%, respectively, to be both significantly positive in the U.S. stock market from 1974 to 2001.

Because the firms with increases in R&D in Taiwan were concentrated in the electronics industry, the sample was separated into firms that were in the electronics industry and those that were in the non-electronics industry in order to explore their differences in this paper. Table 4 displays the long-term abnormal returns for the sub-samples of electronics and non-electronics industry firms. In panel A, the alpha for the electronics industry firms was significantly positive (0.6%) using equal-weighted returns but insignificant using value-weighted returns. In panel B, the alphas for the non-electronics industry firms were significantly negative (-0.54% and -0.4%, respectively) using equal-weighted and value-weighted returns. This result is the same as that of Chan, Martin, and Kensinger (1990) who stated that high-technology firms that announce increases in R&D spending obtain positive abnormal returns but that low-technology firms have negative abnormal returns. This result is also similar to that of Eberhart, Maxwell, and Siddique (2004) who observed that the performance of high-tech firms' R&D investment in the U.S. is better than that of low-tech firms. From the statistics, it can be inferred that the firms in the electronics industry that expend more on R&D will benefit, whereas it will not be advantageous for firms in the non-electronics industry to engage in R&D activity. This might be because firms in non-electronics industry usually spend money on marketing and advertising to boost their sales, and their economies of scale in R&D are too small for them to benefit from R&D.

Similarly, the sample is also separated into firms with high leverage and those with low leverage. The long-term abnormal returns for the sub-samples of high-leverage and low-leverage firms are presented in Table 5. In panels A and B, the alphas for both the high-leverage and low-leverage firms are significantly positive (0.87% and 0.6%) when using equal-weighted returns but insignificant when using value-weighted returns. This result reveals that the high-leverage firms with R&D increases have higher long-term abnormal returns. Such firms may believe their R&D investments will result in abnormal profits, and so they are willing to take on more debt. As for shareholders, based on the benefits of debt monitoring, they will tend to believe that debt as opposed to managerial discretion will reduce agency cost. For managers, debt will tend to limit them from making free use of cash flow, and thus managers will work hard and make good investment decisions because high leverage may lead to bankruptcy (e.g., Jensen, 1966; Grossman and Hart, 1982; Stulz, 1990). In R&D activity, it seems good for firms to raise their debt level appropriately.

From the above, it can be seen that the firms in the electronics industry have higher abnormal returns than those in the non-electronics industry. Then, by adding the factor of leverage, we are able to explore whether electronics firms with high leverage obtain higher abnormal returns. The long-term abnormal stock returns for the different leverage levels of firms with increases in R&D in the electronics industry are presented in Table 6. With equal-weighted returns, the alpha (0.91%) for firms with high-leverage levels in the electronics industry is significantly positively higher than the alpha (-0.75%) for the firms with low-leverage levels. The reason for this may be that most firms in the electronics industry should be innovating as a result of engaging in R&D, and so the firms with higher leverage will be those that obtain more money to support their beneficial R&D projects which will raise their firms' value. In brief, relatively little spending on R&D may result in less profitability from that R&D.

When value-weighted returns are used, the abnormal return estimates are insignificant across all categories of the Fama and French three-factor model except for firms in the non-electronics industry. Loughran and Ritter (2000) noted that the Fama and French three-factor model using value-weighted returns tends to underestimate abnormal returns when the event is regarded as a managerial choice involving cash flows (such as equity issues) rather than routine events (i.e., quarterly earnings announcements). In addition, value-weighted portfolios can also include some periods in which a single firm accounts for a large proportion of the portfolio, resulting in a high variance of returns because this firm's unique risk is not diversified away, and thereby leading to low t-statistics.

5. Conclusions

In this paper, we have empirically examined the effects of leverage on long-term abnormal returns following R&D increases in order to observe the performance of R&D investment in Taiwan. Our sample consisted of 3,390 observations for 645 firms listed on the Taiwan Stock Exchange (TSE) from September 1991 through June 2000 with increases in R&D.

The abnormal returns were measured with calendar-time returns when the ratio of R&D to total assets increased above 5%. Because R&D increases are based on accounting data, and not on formal announcements of increases in R&D, the abnormal returns were not measured using event-time returns. In this paper, the potential benefit of such increases in R&D is regarded as intangible information and the long-term abnormal returns that follow the firms' R&D increases over a five-year period are used to test the efficient markets hypothesis (EMH). The results show that the abnormal returns are ambiguous in terms of providing evidence that the Taiwan market is efficient because the abnormal returns in the sub-samples are not all significant and the abnormal returns are too small. The small abnormal returns may result from the smallness of the scale of R&D conducted in Taiwan.

The overall average intensity of industrial R&D investment in Taiwan falls behind that of the developed countries. Enterprises are the entities that primarily engage in R&D in Taiwan, but Taiwan's industries are dominated by small and medium-sized enterprises, which generally lack the resources needed for R&D. Therefore, the Taiwan government has established a series of financial subsidy policies for enterprises to share their R&D risk. Moreover, Taiwan needs to change its innovation model to encourage more frontier technical innovation or services, and the government should thus concentrate its resources on several farsighted innovation areas that have the potential for development in the future.

It is clear that the R&D investments in Taiwan are mainly concentrated on hi-tech product manufacturing. Our results suggest that the long-term performances of R&D investments in Taiwan's electronics industry are better than those in Taiwan's non-electronics industry. This may in turn suggest that firms in Taiwan's non-electronics industry would not benefit so much from investment in R&D and that their profit would be increased by keeping costs down.

This paper provides evidence that leverage levels significantly affect the abnormal returns of R&D increases. The high-leverage firms with R&D increases have higher abnormal returns than the low-leverage firms. These results correspond to the debt monitoring hypothesis. In particular, in the electronics industry, the high-leverage firms have positive abnormal returns, while the low-leverage firms, by contrast, have negative abnormal returns. One possible reason for this is that firms take on debt to take advantage of economies of scale in good R&D investments, and the other is that debt reduces managerial discretion. To sum up, the agency cost of capital structure model indicates that investors can observe the leverage level of firms when predicting the market's reaction to the quality of R&D.

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Table 1 Descriptive Statistics

Table 1 shows descriptive statistics of the variables based on 3,390 observations of R&D increases for 646 firms from 1991 through 2000. R&D intensity, size and average monthly return are measured as of the beginning of the sample firm's R&D increase month.

	Mean	Median	Std. Deviation
R&D intensity measure :			
R&D/total assets	0.0151	0.0095	0.0179
Size (NT$ million)	18,736.40	5,695	60,992.92
Market value equity/Book value equity (ME/BE)	2.6003	2.19	2.3781
Average monthly return (%)	1.5175	0	13.6862

Table 2 Distribution of Firms with R&D Increases in Industries

Table 2 shows the distribution of all firms in the sample using the two-digit industry code based on the categories of the Taiwan Stock Exchange Corp. from 1991 through 2000.

Industry Code	Industry	Number of firms with increases in R&D/ Total Assets
1100	Cement	12
1200	Food	148
1300	Plastics	184
1400	Textiles	222
1500	Electrical Machinery	316
1600	Appliance Cable	110
1700	Chemical	268
1800	Glass Ceramics	85
1900	Paper and Pulp	97
2000	Iron and Steel	112
2100	Rubber	109
2200	Automobiles	58
2300	Electronics	1,437
2500	Construction	45
2600	Transportation	0
2700	Tourism	0
2900	Wholesale and Retail	0
9900	Others	187
Total		3,390

Table 3 Long-term Abnormal Stock Returns of Firms with R&D Increases - Full Sample

Long-term abnormal stock returns are provided for the full sample of 3,390 observations with R&D increases from 1991 to 2005 using the Fama and French (1993, 1996) three-factor model: $R_{pt} - R_{ft} = \alpha + b(R_{mt} - R_{ft}) + sSMB + hHML_t + \varepsilon_{pt}$, where R_{pt} is the average raw return for stocks in calendar month t (where a sample stock is included if month t is within the 60-month period following its R&D increase), R_{ft} is the average of five major commercial banks' 1-month deposit rates, R_{mt} is the value-weighted market index return, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio with low book-to-market ratios. The intercept (α) in the above equation is the abnormal return measure.

Full Sample				
	Intercept(α *)*	*b*	*s*	*h*
Equal-weighted return	0.0011	1.095	0.9176	-0.7129
	(3.94)***	(14.5)***	(3.12) ***	(-0.46)
Value-weighted return	0.0012	0.3260	-2.3048	-1.2413
	(1.14)	(7.01)***	(-17.86)***	(-2.53) ***

The symbols*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4 Long-term Abnormal Stock Returns of Firms with R&D Increases – Sub-sample

Long-term abnormal stock returns for the electronics sample of 1,437 observations and the non-electronics sample of 2,543 observations with R&D increases from 1991 to 2005 are provided using the Fama and French (1993, 1996) three-factor model: $R_{pt} - R_{ft} = \alpha + b(R_{mt} - R_{ft}) + sSMB + hHML_t + \varepsilon_{pt}$, where R_{pt} is the average raw return for stocks in calendar month t (where a sample stock is included if month t is within the 60-month period following its R&D increase), R_{ft} is the average of five major commercial banks' 1-month deposit rates, R_{mt} is the value-weighted market index return, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio with low book-to-market ratios. The intercept (α) in the above equation is the abnormal return measure.

Panel A: Electronics Sample				
	Intercept(α *)*	*b*	*s*	*h*
Equal-weighted return	0.0060	0.7189	-0.5963	2.3640
	(1.63)*	(11.24)***	(-2.97)***	(1.04)
Value-weighted return	0.0035	0.4734	-1.7947	5.1099
	(1.07)	(4.62) ***	(-7.07)***	(2.55)**
Panel B: Non-Electronics Sample				
	Intercept(α *)*	*b*	*s*	*h*
Equal-weighted return	-0.0054	0.3598	-1.9972	-3.0847
	(-1.73)**	(6.90)***	(-9.71)***	(-1.23)
Value-weighted return	-0.0040	0.1182	-3.2225	-2.9335
	(-4.41)***	(7.23)***	(-49.95)***	(-3.92)***

The symbols*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5 Long-term Abnormal Stock Returns on the Leverage Levels of Firms with R&D Increases – Sub-sample

Long-term abnormal stock returns for the high-leverage sample of 1,696 observations and low-leverage sample of 1,694 observations with R&D increases from 1991 to 2005 are provided using the Fama and French (1993, 1996) three-factor model: $R_{pt} - R_{ft} = \alpha + b(R_{mt} - R_{ft}) + sSMB + hHML_t + \varepsilon_{pt}$, where R_{pt} is the average raw return for stocks in calendar month t (where a sample stock is included if month t is within the 60-month period following its R&D increase), R_{ft} is the average of five major commercial banks' 1-month deposit rates, R_{mt} is the value-weighted market index return, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio with low book-to-market ratios. The intercept (α) in the above equation is the abnormal return measure.

Panel A: High-leverage Sample				
	Intercept(α)	*b*	*s*	*h*
Equal-weighted return	0.0087	0.9898	0.3840	-0.4938
	(2.65)***	(8.96)***	(1.08)	(-0.38)
Value-weighted return	0.0010	0.3475	-2.2312	-0.0501
	(0.83)	(6.69)***	(-14.73)***	(-0.06)
Panel B: Low-leverage Sample				
	Intercept(α)	*b*	*s*	*h*
Equal-weighted return	0.006	0.7747	-0.0071	-3.6339
	(2.61)***	(12.55)***	(-0.30)	(-2.97)***
Value-weighted return	-0.004	0.2221	-2.7391	-2.7374
	(-0.54)	(8.36)***	(-31.41)***	(-4.28)***

The symbols*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6 The Long-term Abnormal Stock Returns on the Leverage Levels of Firms with R&D Increases in the Electronics Industry

Long-term abnormal stock returns for a high-leverage sample of 718 observations and low-leverage sample of 719 observations with R&D increases in the electronics industry from 1991 to 2005 by using the Fama and French (1993, 1996) three-factor model: $R_{pt} - R_{ft} = \alpha + b(R_{mt} - R_{ft}) + sSMB + hHML_t + \varepsilon_{pt}$, where R_{pt} is the average raw return for stocks in calendar month t (where a sample stock is included if month t is within the 60-month period following its R&D increase), R_{ft} is the average of five major commercial banks' 1-month deposit rates, R_{mt} is the value-weighted market index return, SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and HML_t is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio with low book-to-market ratios. The intercept (α) in the above equation is the abnormal return measure.

	Panel A: High-leverage Sample			
	Intercept(α)	*b*	*s*	*h*
Equal-weighted return	0.0091	1.1869	0.7641	-1.4580
	(2.70)***	(10.34)***	(2.12)**	(-0.97)
Value-weighted return	-0.0004	-0.3121	-2.2798	0.6824
	(-0.49)	(8.14)***	(-20.27)***	(1.41)
	Panel B: Low-leverage Sample			
	Intercept(α)	*b*	*s*	*h*
Equal weighted return	-0.0075	-0.0510	-2.1370	-0.1360
	(-1.73)*	(-1.15)	(7.99)***	(-0.04)
Value-weighted return	-0.0033	-0.0038	-2.5582	1.8594
	(-1.62)*	(-0.42)	(-13.95)***	(1.33)

The symbols*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.