
R&D intensity and firm valuation: effect of director and manager incentives

Jang-Shee Barry Lin*

Khalifa University of Science, Technology and Research,
P.O. Box 127788, Abu Dhabi, UAE

Email: barry.lin@kustar.ac.ae

*Corresponding author

Chunhui Liu

Caritas Institute of Higher Education,
18 Chui Ling Road,

Tseung Kwan O, Hong Kong

Email: mliu@cihe.edu.hk

Abstract: Using a sample of 5829 Taiwanese firm-year observations over the 2008–2012 period, we examine the relationship between R&D expenditure and firm valuation. For the whole sample, we find a significant positive association between R&D investment and firm valuation as measured by Market-to-book ratio. However, we also find the dummy variable for Director and Officers liability insurance to be a highly significant variable. Furthermore, we find that the positive association is only effective for the sub-sample of firms with D&O insurance. This is a natural experiment in which we see the critical moderating role played by the incentive of directors and officers as affected by D&O insurance in the relation between R&D spending and firm value.

Keywords: R&D expenditure; firm valuation; market to book ratio; D&O insurance; services and standards.

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Biographical notes: Jang-Shee Barry Lin is an Associate Professor at Khalifa University who has published in journals like *Financial Management*, *Journal of Business and Economic Studies*, *Corporate Ownership and Control* and *Journal of Financial Studies*.

Chunhui Liu is a Professor at Caritas Institute of Higher Education who has published in journals like *Journal of Accounting, Auditing, and Finance*, *Journal of Accounting and Public Policy*, *Issues in Accounting Education*, *Decision Support Systems* and *International Journal of Services and Standards*.

1 Introduction

“Spending more on R&D won’t drive results...” says the 2010 ‘Global Innovation 1000’ report by Booz and Company. A 2015 Mckinsey paper on R&D effectiveness carries the title “Brightening the black box of R&D”, Whether R&D expenditures are effective in value creation has been a perennial question in the minds of executives and business consultants. R&D and capital expenditures often result in cost overrun and delay. Overinvestment is a common problem with US firms, up to 20% of a firm’s cash flow (Richardson, 2006). R&D expenditures are also an easy target for cost cutting when managers face pressure in generating short-term profits since R&D expenditures are expensed rather than capitalised (Knott, 2012).

In terms of empirical evidence, while some studies report a negative effect of R&D expenditures on firm valuation (Guo et al., 2004; Lin and Chen, 2005), many studies report evidence supporting a positive relationship between R&D spending and firm performance (Branch, 1974; Tasse, 1983; Erickson and Jacobson, 1992; Long and Ravenscraft, 1993; Hitt et al., 1991). Chalmers et al. (2002), Eberhart et al. (2004), Munari et al. (2010) and Li (2006) also report evidence of a significant positive correlation between stock price abnormal returns and variations in R&D investments. Comparing younger Hi-tech with older Low-tech firms, Duqi and Torluccio (2013) report evidence that younger and smaller Hi-tech firms experience higher market value effect from R&D spending.

One of the key issues, however, has not been clearly addressed in earlier studies. The issue of managerial and director incentive is critically important in the investment into R&D. Conscientious directors and managers would engage in appropriate R&D expenditure even when facing profit pressure, while opportunistic directors and managers might be tempted to cut R&D expenditure to generate a higher short-term profit.

Directors and Officers’ (D&O) Liability Insurance is an important instrument as an incentive for directors and managers to spend in R&D because D&O liability insurance covers corporate directors and officers against claims arising from their negligent actions as representatives of a firm (Hwang and Kim, 2014). As D&O liability insurance increases the likelihood of attracting valuable outside directors to join the board, reducing conservatism, and lowering the threat of litigation risk (e.g., Core, 1997; O’Sullivan, 2002), the unintended moral hazard can be reduced.

Empirically, some studies report a negative performance after adopting D&O liability insurance (Chalmers et al., 2002; Zou et al., 2008). Lin et al. (2011) reveal that acquirers with a higher level of directors’ liability insurance coverage experience lower announcement-period abnormal stock returns and lower synergies. Two studies find a positive association between this insurance and the cost of debt and equity respectively (Lin et al., 2013; Chen et al., 2016).

Other scholars suggest that firms purchase D&O liability insurance as a regular business practice and that the insurance does not necessarily harm shareholder wealth (Bhagat et al., 1987; Boyer, 2003). Holderness (1990) and O’Sullivan (1997) suggest that D&O liability insurance would strengthen external monitoring and hence prevent the occurrence of managerial wrongdoing.

This study contributes to the literature by advancing the understanding of the role of D&O liability insurance in enhancing firm value from R&D investment in an Asian context. Earlier studies on the relationship between R&D spending and firm value tend to focus on Western countries. In this paper, we use a dataset from Taiwan stock markets,

and provide additional evidence using a sample from the emerging markets. We also contribute to the literature in using D&O liability insurance as an instrument for director and manager incentive in the issue of R&D effectiveness.

The rest of this paper is organised as follows. Section 2 reviews the literature and develops a hypothesis. Section 3 discusses the data and empirical methodologies. Section 4 presents the empirical results. Section 5 concludes the paper.

2 Literature review and hypothesis development

Much research has revealed a positive relationship between R&D and firm value (Ahmed and Falk, 2006; Han and Manry, 2004; Lin and Liu, 2015; Luo et al., 2009; Nekhili et al., 2012; Szewczyk et al., 1996). Duqi and Torluccio (2011) find a strong positive and significant influence of R&D expenditure on firm market value. Chan et al. (2001) find that companies with high R&D to equity market value earn large excess returns. Kallunki et al. (2009) find that the magnitude of stock price response to the R&D spending of a technology firm that's acquiring another technology firm increases by 107% in the year of acquisition. Anagnostopoulou (2008) finds that much research attributes such a positive relation to market compensating for risk from R&D investments. Firm value can be influenced by R&D investments because R&D investments can influence the future profitability of a firm (Branch, 1974) and contribute positively to firm performance (Ehie and Olibe, 2010). Therefore, market participants find both capitalised R&D and R&D expense to be value relevant (Callimaci and Landry, 2004).

R&D involves a high level of risk and uncertainty (Moehrle and Walter, 2008). For example, in 2003, Daimler-Chrysler recognised more than \$250 million running losses when DaimlerChrysler and Deutsche Telekom founded a joint venture named Toll Collect to develop and build a highway truck-toll-collection system for the German government (Edmondson et al., 2004).

As per agency theory, shareholders may not be able to benefit from high risk/high return strategies associated with R&D investments because risk-adverse managers tend to prefer short-term gains through efficiency-seeking strategies leading to a reduction in R&D and capital expenditures (Barger et al., 2010; Cohen et al., 2009; Liu, 2015; Ortiz et al., 2013). In addition, members of the board of directors of publicly traded corporations face personal liability for breach of duties of care to the company's shareholders (Romano, 1991). Liability exposure may induce managers and directors to be overly conservative and lead them to forego risky positive net present value projects (Boyer and Tennyson, 2015).

D&O insurance policies provide coverage to a company's officers and directors against risks arising from day-to-day management (Boyer and Tennyson, 2015) and attract competent and talented directors and officers (Mayers and Smith, 1982). A recent study (Hwang and Kim, 2014) finds that D&O insurance leads to a more risk-taking behaviour of firms.

Moreover, Chan et al. (2015) find that R&D-intensive firms indeed earn higher stock returns when they have well-established corporate governance because good governance is able to prevent potential overinvestment in R&D spending and to increase the rate of return for R&D spending firms. Pindado et al. (2015) find that effective control mechanisms reinforce the positive effect of R&D on a firm's market value. D&O insurers can provide valuable monitoring services to the firm like scrutinising its governance

structure during the underwriting process (Core, 1997, 2000). Insurers engage in extensive pre-sale monitoring of potential purchasers of D&O insurance (Baker and Griffith, 2009). Holderness (1990) indicates that insurers may negotiate changes in a firm's corporate governance as a condition for obtaining insurance such as increasing the number of outsiders on the audit committee. O'Sullivan (1997) finds that the purchase of D&O insurance is positively related to firm size and negatively related to insider ownership of shares. Boyer and Tennyson (2015) find that D&O insurance coverage to associate with stronger corporate governance. Since D&O insurance encourages optimal risk taking (Boyer and Tennyson, 2015), we hypothesise that

H₁: R&D spending and firm values are positively associated.

H₂: D&O insurance coverage increases the positive association between firm value and R&D spending.

3 Data and methodology

3.1 Data, sample selection and key variables

Our sample incorporates the annual financial results of listed firms traded on either the Taiwan Stock Exchange (TSE) or GreTai Securities Market (OTC) for the sampling period from 2008 to 2012. All variables of the observations are extracted from the Taiwan Economic Journal database, which is comparable to CRSP/Compustat merged database. Considering the differences in regulations and accounting periods, we exclude firms in finance and utility industries as well as non-trading and non-December fiscal year-end firms. Over this sampling period, 16 firms stopped buying the D&O insurance in some years, three of which repurchased the insurance in other years. To avoid the impact of such outliers, we exclude these 16 firms. After excluding firms with missing values in the variables used, our final data contains 5829 firm-year observations of 1303 firms. These firms come from across all 29 industrial categories in Taiwan as per Table 1. In our robustness test, all variables are winsorised at the top and bottom 1% level.

Table 1 reports the percentage of firms in each industrial category by year and 5-year average. It is clear that the variation in the percentage properly reflects the industrial landscape of Taiwan. Of the 29 industrial categories (currently category numbers 7 and 13 are not in use, and Category 19 is for Miscellaneous and contains no observations) many traditional industries represent less than 1% of firms, while High-tech industries have the highest percentages. Many firms are in industries where R&D is critical: Electronic Parts/Components (14.41%), Semiconductor (9.55%), Optoelectric (8.37%), Computer and Peripheral (8.34%) and Communications and Internet (5.47%) (based on 5-year average).

Table 2 reports mean value of firm characteristics variables across industry categories. Confirming results in Table 1, traditional industries represent a smaller number of observations while High-tech industries offer more observations. In terms of firm age, traditional industries have higher firm age, while the average age of all High-tech industries is lower than the total average of 36 years. We also observe that in terms of the adoption of D&O liability insurance, High-tech firms have the higher percentage of D&O adoption around 70%, while 30 ~ 40% traditional industries have adopted D&O. When we look at R&D ratio, the High-tech industries also have significantly higher

ratios. The five industries with highest R&D expenditure ratio are Biotech and Medical Care (27.27%), Information Service (11.76%), Semiconductor (11.1%), Computer and Peripheral (5.78%) and Communications and Internet (5.68%). In terms of ownership structure, High-tech industries tend to have higher insider ownership around 2%, while most of the other industries have insider ownership lower than 1%. This provides an explanation/rationale for their higher percentage in the adoption of D&O liability insurance. Above patterns in firm characteristics give a preliminary indication of the relation among D&O liability insurance, R&D expenditure and firm performance.

3.2 Methodology

We use the following OLS regression to investigate the relationship between firm performance and R&D investment. If H_1 holds true, β_1 is expected to be positive and significant. To test H_2 , we investigate this relation for firms with D&O insurance and firms without separately after removing β_2 D&O Incentive from the model. If H_2 holds true, β_1 is expected to be significantly positive to a greater extent for firms with D&O insurance.

$$MB_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 \text{D\&O Incentive} + \beta_3 X_{it} + v_{it},$$

where MB_{it} is Firm i 's market-to-book ratio in Year t ; RD_{it} is annual R&D expense as a percentage of sales revenue; D&O Incentive is a dummy variable with a value 1 for firms with D&O liability insurance, and value 0 otherwise; X_{it} is a set of exogenous control variables, and v_{it} is the error term.

The MB ratio has been a common measure of firm value for over two decades used by many scholars like Cheung et al. (2011), Hoi and Robin (2010) and Pérez-González and Yun (2013). We follow many earlier studies in using MB ratio as a measure of firm valuation (e.g., Fich and Shivdasani, 2006). Market to book ratio is the sum of the market value of shares outstanding at the end of the year and total debts divided by total assets. RD investment has been measured by R&D expense over sales revenue ratio in numerous previous studies (e.g., Duqi and Torluccio, 2013; Knott, 2012).

The control variables are chosen based on prior studies (Morck et al., 1988; Yermack, 1996; among others), which include institutional ownership, insider ownership, board size, board independence, long-term debt ratio, fixed asset ratio, a log of total assets and sales growth rate. Cheung et al. (2011) observe that there is a positive and statistically significant correlation between the changes in the quality of corporate governance practices and subsequent changes in market valuation as measured by market-to-book ratio. Therefore, measures of governance practice are included as control variables. Below are definitions of independent variables:

Instp (Institutional ownership): percentage of shares held by financial institutions such as mutual funds and pension funds.

Insdp (Insider ownership): percentage of shares held by corporate managers and officers.

Board (Board size): the number of board members.

Board_indp (Board independence): the percentage of outside directors on the board.

LTDTA (Long-Term debt ratio): long-term debt as a percentage of total assets, a measure of leverage.

Log_TA (Log of total assets): a measure of firm size.

Sales_Growth (Sales growth): year on year change in sales.

FATA (Fixed asset ratio): fixed assets as a percentage of total assets.

Table 1 Sample industry distribution (% of firms, by year)

| <i>Code</i> | <i>Industry</i> | <i>2008</i> | <i>2009</i> | <i>2010</i> | <i>2011</i> | <i>2012</i> | <i>Average</i> |
|-------------|----------------------------------|-------------|-------------|-------------|-------------|-------------|----------------|
| 01 | Cement | 0.63% | 0.60% | 0.61% | 0.59% | 0.57% | 0.60% |
| 02 | Food | 2.08% | 1.97% | 1.92% | 1.76% | 1.64% | 1.88% |
| 03 | Plastic | 2.45% | 2.31% | 2.36% | 2.27% | 2.29% | 2.34% |
| 04 | Textile and fibre | 4.35% | 4.45% | 4.20% | 3.61% | 3.77% | 4.07% |
| 05 | Elec. engi. and machine | 5.07% | 5.22% | 4.72% | 5.12% | 4.83% | 4.99% |
| 06 | Appliance and cable | 1.27% | 1.20% | 1.22% | 1.34% | 1.31% | 1.27% |
| 08 | Glass and ceramics | 0.36% | 0.34% | 0.35% | 0.34% | 0.33% | 0.34% |
| 09 | Paper | 0.63% | 0.60% | 0.61% | 0.59% | 0.57% | 0.60% |
| 10 | Steel and iron | 3.35% | 3.17% | 3.15% | 2.94% | 2.95% | 3.11% |
| 11 | Rubber | 1.00% | 0.94% | 0.79% | 0.84% | 0.74% | 0.86% |
| 12 | Auto | 0.45% | 0.43% | 0.17% | 0.34% | 0.41% | 0.36% |
| 14 | Construction | 5.43% | 5.39% | 5.07% | 4.95% | 4.67% | 5.10% |
| 15 | Sea transport | 1.81% | 1.88% | 1.84% | 1.76% | 1.80% | 1.82% |
| 16 | Tourism | 1.00% | 0.94% | 0.96% | 0.84% | 1.23% | 0.99% |
| 17 | Finance and insurance | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| 18 | Wholesale and retailing | 1.63% | 1.71% | 1.57% | 1.51% | 1.47% | 1.58% |
| 20 | Other | 5.34% | 5.39% | 5.24% | 5.21% | 5.00% | 5.24% |
| 21 | Chemical | 3.17% | 3.17% | 2.88% | 3.11% | 2.87% | 3.04% |
| 22 | Biotech and medical care | 3.26% | 3.34% | 3.50% | 4.20% | 5.00% | 3.86% |
| 23 | Oil, gas and electricity | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| 24 | Semiconductor | 9.15% | 8.98% | 9.79% | 9.91% | 9.91% | 9.55% |
| 25 | Computer and peripheral | 8.42% | 8.47% | 8.48% | 8.23% | 8.11% | 8.34% |
| 26 | Optoelectric | 7.61% | 8.13% | 8.39% | 8.73% | 9.01% | 8.37% |
| 27 | Communications and internet | 5.43% | 5.30% | 5.42% | 5.54% | 5.65% | 5.47% |
| 28 | Electronic parts/components | 14.13% | 14.20% | 14.86% | 14.61% | 14.25% | 14.41% |
| 29 | Electronic products distribution | 3.44% | 3.34% | 3.32% | 3.19% | 3.11% | 3.28% |
| 30 | Information service | 3.26% | 3.25% | 2.88% | 3.19% | 3.19% | 3.16% |
| 31 | Other electronic | 5.25% | 5.30% | 5.68% | 5.29% | 5.32% | 5.37% |

The sample consists of 5829 firm-year observations of 1303 listed firms in Taiwan from 2008 to 2012. This table reports industry distribution of sample firms across the 29 industrial categories for stocks listed in Taiwan Stock Exchange. Due to significantly different legal and regulatory frameworks, following earlier studies, firms in Industry Category 17: Finance and Insurance and in the utilities industry, Industry Category 23: Oil, Gas and Electricity are excluded. Reported numbers are percentages of firms in each industry for each of the five years from 2008 to 2012 and for the total five-year period. Industrial codes 7 and 13 are currently not used. Industrial Code 19 is for miscellaneous and contains no observations.

Table 2 Sample firm characteristics (by industry)

| <i>Code</i> | <i>Industry</i> | <i>Obs.</i> | <i>Age</i> | <i>Dodum</i> | <i>rdr%</i> | <i>ltdta%</i> | <i>0.03</i> | <i>insdp%</i> | <i>instp%</i> |
|--------------------------------------|----------------------------------|-------------|------------|--------------|-------------|---------------|-------------|---------------|---------------|
| 01 | Cement | 35 | 55 | 0.31 | 0.10 | 10.14 | 11.89 | 0.13 | 52.41 |
| 02 | Food | 109 | 45 | 0.35 | 0.39 | 9.20 | 9.22 | 0.82 | 38.50 |
| 03 | Plastic | 136 | 43 | 0.35 | 1.11 | 9.63 | 9.87 | 0.33 | 36.06 |
| 04 | Textile and Fibre | 237 | 40 | 0.11 | 0.83 | 7.22 | 9.43 | 1.78 | 33.68 |
| 05 | Elec. engi. and machine | 291 | 35 | 0.37 | 2.83 | 8.26 | 9.95 | 1.04 | 32.15 |
| 06 | Appliance and cable | 74 | 43 | 0.34 | 0.57 | 8.12 | 9.74 | 0.33 | 29.54 |
| 08 | Glass and ceramics | 20 | 46 | 0.25 | 1.59 | 7.42 | 9.20 | 0.04 | 33.45 |
| 09 | Paper | 35 | 53 | 0.29 | 0.23 | 11.30 | 10.57 | 0.19 | 44.81 |
| 10 | Steel and iron | 181 | 38 | 0.41 | 0.29 | 11.73 | 9.15 | 0.85 | 38.54 |
| 11 | Rubber | 50 | 48 | 0.24 | 1.30 | 7.46 | 10.34 | 0.34 | 35.90 |
| 12 | Auto | 21 | 47 | 0.24 | 2.47 | 3.14 | 13.62 | 0.06 | 69.80 |
| 14 | Construction | 297 | 34 | 0.34 | 0.48 | 5.01 | 8.75 | 0.93 | 44.01 |
| 15 | Sea transport | 106 | 43 | 0.43 | 0.02 | 14.27 | 10.26 | 0.60 | 52.27 |
| 16 | Tourism | 58 | 40 | 0.21 | – | 6.47 | 9.22 | 0.17 | 48.43 |
| 18 | Wholesale and retailing | 92 | 34 | 0.36 | 0.13 | 11.10 | 9.51 | 1.05 | 50.26 |
| 20 | Other | 305 | 33 | 0.51 | 1.17 | 8.14 | 9.16 | 0.70 | 39.68 |
| 21 | Chemical | 177 | 40 | 0.32 | 1.38 | 4.79 | 9.84 | 0.87 | 37.41 |
| 22 | Biotech and medical care | 226 | 28 | 0.58 | 27.27 | 6.37 | 9.48 | 1.54 | 26.64 |
| 24 | Semiconductor | 557 | 21 | 0.73 | 11.10 | 6.59 | 9.37 | 1.96 | 36.32 |
| 25 | Computer and peripheral | 486 | 25 | 0.73 | 5.78 | 3.58 | 8.84 | 1.95 | 33.89 |
| 26 | Optoelectric | 489 | 22 | 0.75 | 4.01 | 9.07 | 9.39 | 1.51 | 34.10 |
| 27 | Communications and internet | 319 | 23 | 0.77 | 5.68 | 4.79 | 9.52 | 2.03 | 33.20 |
| 28 | Electronic parts/components | 840 | 27 | 0.60 | 2.55 | 5.54 | 9.32 | 2.07 | 29.33 |
| 29 | Electronic products distribution | 191 | 25 | 0.76 | 0.50 | 3.51 | 9.06 | 3.58 | 30.09 |
| 30 | Information service | 184 | 23 | 0.71 | 11.76 | 0.97 | 9.29 | 2.78 | 31.74 |
| 31 | Other electronic | 313 | 28 | 0.70 | 5.35 | 5.14 | 8.91 | 2.18 | 35.17 |
| <i>Average across all industries</i> | | <i>224</i> | <i>36</i> | <i>0.45</i> | <i>3.42</i> | <i>7.27</i> | <i>9.73</i> | <i>1.15</i> | <i>38.74</i> |

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Sales growth, firm size (e.g., Log-TA), and leverage (e.g., LTDTA) have been used as control variables to explain variations in firm value (Min and Verhoeven, 2013). Giráldez and Hurtado (2014) find firm size, board size (Board), and board independence (Board_indp) to be significantly associated with firm value. Fan and Yu (2016) reveal the influence of percentage of institutional holdings (Instp), percentage of insider holdings (Insdp), and sales growth on firm value. Empirical evidence suggests that fixed asset ratio influences monitoring and governance that associate with firm value (Fan and Yu, 2016). Morck et al. (1988) and Yermack (1996) also used similar control variables in their studies.

4 Empirical results

Table 3 reports and compares the mean value of the variables for the two sub-samples: firms with D&O liability insurance vs. firms without D&O liability insurance. While most of the variables are quite similar, there are two variables with a substantial difference in magnitude. Board independence (% independent directors on the board) is twice as large for firms with D&O liability insurance, indicating a better governance structure in agreement with earlier findings (Boyer and Tennyson, 2015; O'Sullivan, 1997). In addition, the firms with D&O coverage also have a higher R&D expense ratio at 5.52% of revenue in comparison to 3.57% for firms without, confirming the finding by Hwang and Kim (2014) that D&O coverage encourages the risk taking behaviour. These two differences give the first indication that D&O insurance, with its incentive effect, may be associated with a different relation between R&D intensity and firm performance.

Table 4 reports the full-sample OLS regression results of the effect of R&D expenditure on market valuation as measured by market-to-book ratio. In support of H₁, R&D Intensity is positive and highly significant, consistent with several earlier studies (e.g., Ahmed and Falk, 2006; Bae and Kim, 2003; Callimaci and Landry, 2004; Ho et al., 2004; Lin and Liu, 2015; Luo et al., 2009; Nekhili et al., 2012; Szewczyk et al., 1996). D&O_Incentive is positive and also highly significant, indicating a positive association between adoption of D&O liability insurance and firm valuation in agreement with Duqi and Torluccio (2011).

With respect to corporate governance variables, consistent with previous studies (McConnell and Servaes, 1990), we document a positive relation between firm valuation and institution ownership and a negative relationship between firm valuation and insider ownership. For the other control variables, firm size is negatively associated with firm valuation, indicating a reverse size effect, or, a small firm effect. This is consistent with prior findings (Duqi and Torluccio, 2013; Fan and Yu, 2016). Yermack (1996) finds that board size affects firm performance negatively. In our Taiwanese sample, board size is positive but insignificant. This may indicate differences in corporate culture (Liu and O'Farrell, 2013) and differences in corporate governance practices between Taiwan and the US. In particular, while many US firms have a sizeable board, Taiwanese firms have, in comparison, smaller boards. While US boards might exhibit more of a redundancy issue, Taiwanese boards might, on the other hand, exhibit more of an issue of lack of resources. Board independence, on the other hand, is negative, though only weakly

significantly, associated with market-to-book. This is likely related to the relatively new practice of paying attention to outside directors in Taiwan (and more broadly in other Far East markets). Traditionally, Taiwanese firms are characterised by having directors with close connections to the firm, and thus less board independence as compared to US firms.

Table 3 Univariate analysis (by D&O adoption)

| | <i>D&O = 0</i> | <i>D&O = 1</i> |
|--------------|--------------------|--------------------|
| MB | 1.2486974** | 1.3696198** |
| Instp | 33.8734842*** | 36.2349173*** |
| Insdp | 1.2868396*** | 1.8256001*** |
| Board | 9.2602419*** | 9.4543784*** |
| Board_indp | 8.2417834*** | 16.6429224*** |
| R&D | 3.5758564*** | 5.5237171*** |
| LTDTA | 6.0878878*** | 6.9048217*** |
| FATA | 22.6547928*** | 18.6153586*** |
| Log_TA | 15.02997*** | 15.2799718*** |
| Sales_Growth | 27.7330745 | 29.2192407 |
| <i>N</i> | 2563 | 3266 |

The sample consists of 5829 firm-year observations of 1303 listed firms in Taiwan from 2008 to 2012. Market to book ratio is the market value of shares outstanding at the end of the year plus total debts then divided by total assets. Insider and institutional ownership is the percentage of shares held by firm managers and institutional investors respectively. Board size is the number of board members. Board independence is a percentage of independent directors on the board. R&D expense ratio is the percentage of annual research and development expense divided by sales revenue. The long-term debt ratio is the percentage of assets financed by long-term debt. Fixed asset ratio is the percentage of fixed assets in total assets. Log total assets are the natural logarithm of total assets. Sales growth is the % growth in sales revenue. All variables are extracted from the *Taiwan Economic Journal (TEJ)*. *, **, and *** indicate significance levels at 10%, 5%, and 1% respectively.

In Table 5, we divide the full-sample into two sub-samples: firms with D&O liability insurance and firms without D&O liability insurance. The same OLS regression is run on the two sub-samples. While most variables retain similar results as in the full-sample results in Table 4, R&D Intensity shows important different results between the two sub-samples. R&D is highly significant and positive only for the sub-sample of firms with D&O liability insurance, while it is insignificant for the sub-sample of firms without D&O liability insurance. This finding supports H_2 and confirms the suggestion in earlier studies that D&O liability insurance is associated with better director and manager incentive (Boyer and Tennyson, 2015) or with better monitoring and governance (Baker and Griffith, 2009; Boyer and Tennyson, 2015; Core, 1997, 2000). Interestingly, the reverse size effect still maintains.

As a robustness test, in Table 6, we winsorise the variables at 1% level and re-run the OLS regression in Table 5. The results in Table 6 provide confirmation of earlier results that

- there is a positive and significant relationship between R&D investment and firm valuation only for the sub-sample of firms with D&O liability insurance
- there is a significant small-firm effect in the relationship between R&D investments and firm valuation.

Table 4 OLS regression

| | <i>Parameter estimates</i> | <i>t statistics</i> |
|-----------------------|----------------------------|---------------------|
| Intercept | 3.69202*** | 11.85 |
| D&O_Incentive | 0.1487*** | 2.85 |
| Insdp | -0.02916*** | -2.85 |
| Instp | 0.0104*** | 8.33 |
| Board | 0.01736 | 1.48 |
| Board_indp | -0.00338* | -1.75 |
| R&D | 0.00291*** | 3.2 |
| LTDTA | 0.00546** | 1.97 |
| FATA | -0.00031936 | -0.22 |
| Log_TA | -0.22464*** | -10.25 |
| Sales_Growth | -0.00000199 | -0.09 |
| <i>N</i> | 5829 | |
| F-stat | 7.74 | |
| <i>R</i> ² | 0.0121 | |

The sample consists of 5829 firm-year observations of 1303 listed firms in Taiwan from 2008 to 2012. Market to book ratio is the market value of shares outstanding at the end of the year plus total debts then divided by total assets. Insider and institutional ownership is the percentage of shares held by firm managers and institutional investors respectively. Board size is the number of board members. Board independence is a percentage of independent directors on the board. R&D expense ratio is the percentage of research and development expenditure in revenue. The long-term debt ratio is the percentage of assets financed by long-term debt. Fixed asset ratio is the percentage of fixed assets in total assets. Log total assets are the natural logarithm of total assets. Sales growth is the % growth in sales revenue. R&D expense ratio is the percentage of annual research and development expense divided by sales revenue. All variables are extracted from the *Taiwan Economic Journal (TEJ)*. *, **, and *** indicate significance levels at 10%, 5%, and 1% respectively.

Table 5 OLS regression

| | <i>D&O = 0</i> | <i>D&O = 1</i> |
|------------|--------------------|--------------------|
| Intercept | 4.20608*** | 3.63935*** |
| Insdp | -0.04356** | -0.02066* |
| Instp | 0.00861*** | 0.01208*** |
| Board | 0.03101* | 0.00239 |
| Board_indp | -0.00239 | -0.00461** |
| R&D | 0.00138 | 0.00529*** |
| LTDTA | 0.00795 | 0.00418 |
| FATA | -0.00239 | 0.00111 |

Table 5 OLS regression (continued)

| | <i>D&O = 0</i> | <i>D&O = 1</i> |
|-----------------------|--------------------|--------------------|
| Log_TA | -0.20787*** | -0.26002*** |
| Sales_Growth | -0.00001645 | -6.3676E-07 |
| <i>N</i> | 2563 | 3266 |
| F-stat | 5.38 | 13.23 |
| <i>R</i> ² | 0.0186 | 0.0353 |

The sample consists of 5829 firm-year observations of 1303 listed firms in Taiwan from 2008 to 2012. Market to book ratio is the market value of shares outstanding at the end of the year plus total debts then divided by total assets. Insider and institutional ownership is the percentage of shares held by firm managers and institutional investors respectively. Board size is the number of board members. Board independence is a percentage of independent directors on the board. R&D expense ratio is the percentage of research and development expenditure in revenue. The long-term debt ratio is the percentage of assets financed by long-term debt. Fixed asset ratio is the percentage of fixed assets in total assets. Log total assets are the natural logarithm of total assets. Sales growth is the % growth in sales revenue. R&D expense ratio is the percentage of annual research and development expense divided by sales revenue. All variables are extracted from the *Taiwan Economic Journal (TEJ)*. *, **, and *** indicate significance levels at 10%, 5%, and 1% respectively.

Table 6 OLS regression

| | <i>D&O = 0</i> | <i>D&O = 1</i> |
|-----------------------|--------------------|--------------------|
| Intercept | 5.06986*** | 4.61222*** |
| Insdp | -0.03374* | -0.01229 |
| Instp | 0.00838*** | 0.01233*** |
| Board | 0.02153 | 0.00187 |
| Board_indp | -0.00109 | -0.00298 |
| R&D | 0.00118 | 0.00513*** |
| LTDTA | 0.00323 | 0.00032 |
| FATA | -0.00636*** | -0.00273 |
| Log_TA | -0.27490*** | -0.23657*** |
| Sales_Growth | -0.00000133 | -0.00000147 |
| <i>N</i> | 2563 | 3266 |
| F-stat | 6.5 | 15.6 |
| <i>R</i> ² | 0.0224 | 0.0414 |

The sample consists of 5,829 firm-year observations of 1303 listed firms in Taiwan from 2008 to 2012. Market to book ratio is the market value of shares outstanding at the end of the year plus total debts then divided by total assets. Insider and institutional ownership is the percentage of shares held by firm managers and institutional investors respectively. Board size is the number of board members. Board independence is a percentage of independent directors on the board. R&D expense ratio is the percentage of research and development expenditure in revenue. The long-term debt ratio is the percentage of assets financed by long-term debt. Fixed asset ratio is the percentage of fixed assets in total assets. Log total assets are the natural logarithm of total assets. Sales growth is the % growth in sales revenue. R&D expense ratio is the percentage of annual research and development expense divided by sales revenue. All variables are extracted from the *Taiwan Economic Journal (TEJ)*. *, **, and *** indicate significance levels at 10%, 5%, and 1% respectively.

5 Summary and conclusions

This paper investigates the important issue of R&D expenditure and firm valuation by using a sample of Taiwanese firms from 2008 to 2012. In particular, we investigate the important issue of director and manager incentive in moderating the relation between R&D expense and firm performance. As most of the earlier studies focused on western economies, this paper provides additional independent evidence from Taiwan, an emerging market. We find a significant positive association between R&D investment and firm valuation as measured by market-to-book ratio. In addition, when we divide the full-sample into sub-samples with and without D&O liability insurance, we find that the positive and significant association between firm valuation and R&D only exists for sub-sample of firms with D&O liability insurance. R&D expenditure becomes an insignificant variable for firm valuation for firms without D&O liability insurance.

Comparable to other studies, we find some governance variables such as board characteristics and ownership structure variables, to be significant, although the board variables are significant in ways somewhat different from the typical results found in US data. Finally, we document a significant small-firm effect in the relationship between firm valuation and R&D investments, indicating that R&D generates more value for small firms. This result confirms the general perception that innovative small high-tech firms in Taiwan are successful in utilising R&D investments in developing value-creating innovations.

It is worthwhile to consider the following caveats in applying our findings. First of all, the findings are constrained by limitations of OLS regression. We have robust tested our findings by winsorising all variables at the top and bottom 1% level to address possible concerns with outliers. In addition, our findings are made based on data on firms in Taiwan. Precaution should be taken when generalising the findings to other contexts.

Our empirical findings contribute to the literature in providing new understanding in the important area of R&D investments and firm valuation, particularly in the role of D&O insurance as an incentive for directors and managers' optimal level of risk taking. Policy makers in the past did not permit firms to use D&O liability insurance to indemnify their directors and officers from claims so as to hold them personally liable for breach of duties of care to protect shareholders' interest. Consistent with prior findings, our study finds that D&O insurance does not necessarily harm shareholder interests. Our findings reveal that the insurance encourages directors and officers to make optimal R&D investment to enhance firm value.

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References

- Ahmed, K. and Falk, H. (2006) 'The value relevance of management's policy choice of research and development expenditure reporting: evidence from Australia', *Journal of Accounting and Public Policy*, Vol. 25, No. 4, pp.231–264.

- Anagnostopoulou, S.C. (2008) 'R&D expenses and firm valuation: a literature review', *International Journal of Accounting and Information Management*, Vol. 16, No. 1, pp.5–24.
- Bae, S. and Kim, D. (2003) 'The effect of R&D investments on market value of firms: evidence from the U.S., Germany and Japan', *Multinational Business Review*, Vol. 11, pp.51–75.
- Baker, T. and Griffith, S.J. (2009) 'How the merits matter: D&O insurance and securities settlements', *University of Pennsylvania Law Review*, Vol. 157, pp.755–832.
- Bargeron, L.L., Lehn, K.M. and Zutter, C.J. (2010) 'Sarbanes-Oxley and corporate risk-taking', *Journal of Accounting and Economics*, Vol. 49, No. 1–2, pp.34–52.
- Bhagat, S., Brickley, J.A. and Coles, J.L. (1987) 'Managerial indemnification and liability insurance: the effect on shareholder wealth', *The Journal of Risk and Insurance*, Vol. 54, pp.721–736.
- Boyer, M. and Tennyson, S. (2015) 'Directors' and officers' liability insurance, corporate risk and risk taking: new panel data evidence on the role of directors' and officers' liability insurance', *Journal of Risk and Insurance*, Vol. 82, No. 4, pp.753–791.
- Boyer, M.M. (2003) *is the Demand for Corporate Insurance a Habit? Evidence from Directors' and Officers' Insurance*, CIRANO Working Paper.
- Branch, B. (1974) 'Research and development activity and profitability', *Journal of Political Economy*, Vol. 82, No. 5, pp.999–1011.
- Callimaci, A. and Landry, S. (2004) 'Market valuation of research and development spending under Canadian GAAP', *Canadian Accounting Perspectives*, Vol. 3, No. 1, pp.33–53.
- Chalmers, J.M.R., Dann, L.Y. and Harford, J. (2002) 'Managerial opportunism? evidence from directors' and officers' insurance purchases', *The Journal of Finance*, Vol. 57, pp.609–636.
- Chan, K., Chen, H.K., Hong, L.H. and Wang, Y.Z. (2015) 'Stock market valuation of R&D expenditures – the role of corporate governance', *Pacific-Basin Finance Journal*, Vol. 31, pp.78–93.
- Chan, L.K.C., Lakonishock, J. and Sougiannis, T. (2001) 'The stock market valuation of research and development expenditures', Vol. 56, No. 6, pp.2431–2456.
- Chen, Z., Li, O.Z. and Zou, H. (2016) 'Directors' and officers' liability insurance and the cost of equity', *Journal of Accounting and Economics*, Vol. 61, pp.100–120.
- Cheung, Y.L., Connelly, J.T., Jiang, P. and Limpaphayom, P. (2011) 'Does corporate governance predict future performance? evidence from Hong Kong', *Financial Management*, Vol. 40, No. 1, pp.159–197.
- Cohen, D., Deys, A. and Lys, T. (2009) *The Sarbanes-Oxley Act of 2002: Implications for Compensation Contracts and Managerial Risk-Taking*, Working Paper, New York University Stern School of Business.
- Core, J.E. (1997) 'On the corporate demand for directors' and officers' insurance', *The Journal of Risk and Insurance*, Vol. 64, pp.63–87.
- Core, J.E. (2000) 'The director's and officers' insurance premium: an outside assessment of the quality of corporate governance', *Journal of Law, Economics and Organization*, Vol. 16, pp.449–477.
- Duqi, A. and Torluccio, G. (2013) 'The impact of R&D on the value of European firms', *International Journal of Accounting, Auditing and Performance Evaluation*, Vol. 9, pp.1–26.
- Duqi, A. and Torluccio, G. (2011) 'Can R&D expenditures affect firm market value? an empirical analysis of a panel of European listed firms', in Molyneux, P. (Ed.): *Bank Performance, Risk and Firm Financing*, Palgrave Macmillan, London, pp.215–241.
- Eberhart, A.C., Maxwell, W.F. and Siddique, A.R. (2004) 'An examination of long-term excess stock returns and operating performance following R&D increases', *Journal of Finance*, Vol. 59, pp.623–651.

- Edmondson, A.C., Roberto, M.A., Bohmer, R.M.J., Ferlins, E.M. and Feldman, L.R. (2004) *The Recovery Window: Organizational Learning Following Ambiguous Threats in High-Risk Organizations*, Working Paper, Harvard Business School, Division of Research – Boston, Mass, ISSN 0749-4610, Zdb-ID 2616828. – Vol. 05, 012.
- Ehie, I.C. and Olibe, K. (2010) ‘The effect of R&D investment on firm value: an examination of US manufacturing and service industries’, *International Journal of Production Economics*, Vol. 128, No. 6, pp.127–135.
- Erickson, G. and Jacobson, R. (1992) ‘Gaining comparative advantage through discretionary expenditures: the returns to R&D and advertising’, *Management Science*, Vol. 38, pp.1264–1279.
- Fan, S.Z. and Yu, L. (2016) ‘Variation in corporate governance and firm valuation – an international study’, *International Review of Finance*, Vol. 16, No. 4, pp.525–563.
- Fich, E.M. and Shivdasani, A. (2006) ‘Are busy boards effective monitors?’, *The Journal of Finance*, Vol. 61, pp.689–724.
- Guo, R., Lev, B. and Zhou, N. (2004) ‘Competitive costs of disclosure by biotech IPOs’, *Journal of Accounting Research*, Vol. 42, pp.319–355.
- Han, B.H. and Manry, D. (2004) ‘The value-relevance of R&D and advertising expenditure: Evidence from Korea’, *The International Journal of Accounting*, Vol. 39, No. 2, pp.155–173.
- Hitt, M., Hoskisson, R., Ireland R. and Harrison, J. (1991) ‘Effects of acquisition on R&D inputs and outputs’, *Academy of Management Journal*, Vol. 34, pp.693–706.
- Ho, Y.K., Xu, Z. and Yap, C.M. (2004) ‘R&D investment and systematic risk’, *Accounting and Finance*, Vol. 44, pp.393–418.
- Hoi, C.K. and Robin, A. (2010) ‘Agency conflicts, controlling owner proximity and firm value: an analysis of dual-class firms in the United States’, *Corporate Governance: An International Review*, Vol. 18, No. 2, pp.124–135.
- Holderness, G.G. (1990) ‘Liability insurers as corporate monitors’, *International Review of Law and Economics*, Vol. 10, pp.115–129.
- Hwang, J.H. and Kim, B. (2014) ‘Directors’ and officers’ liability insurance and corporate risk-taking’, *Insurance Risk and Finance Research Centre (IRFRC) 2014 Conference*, Singapore.
- Kallunki, J., Pyykkö, E. and Laamanen, T. (2009) ‘Stock market valuation, profitability and R&D spending of the firm: the effect of technology mergers and acquisitions’, *Journal of Business Finance and Accounting*, Vol. 36, Nos. 7–8, pp.838–862.
- Knott, A. (2012) ‘The trillion-dollar R&D fix’, *Harvard Business Review*, Vol. 90, No. 5, pp.76–82.
- Li, W.C. (2006) *Global Sourcing in Innovation: Theory and Evidence from the Information Technology Hardware Industry*, Working Paper, University of California, Los Angel.
- Lin, B.W. and Chen, J.S. (2005) ‘Corporate technology portfolios and R&D performance measures: a study of technology intensive firms’, *R&D Management*, Vol. 35, pp.157–170.
- Lin, C., Officer, M.S. and Zou, H. (2011) ‘Directors’ and officers’ liability insurance and acquisition outcomes’, *Journal of Financial Economics*, Vol. 102, pp.507–525.
- Lin, C., Officer, M.S., Wang, R. and Zou, H. (2013) ‘Directors’ and officers’ liability insurance and loan spreads’, *Journal of Financial Economics*, Vol. 110, pp.37–60.
- Lin, J.S. and Liu, C. (2015) ‘R&D, corporate governance, firm size and firm valuation evidence from Taiwanese companies’, *International Journal of Corporate Governance*, Vol. 6, No. 2, pp.87–97.
- Liu, C. and O’Farrell, G. (2013) ‘The impact of XBRL on forecast accuracy across nations’, *International Journal of Services and Standards*, Vol. 8, No. 3, pp.247–263.
- Liu, C. (2015) ‘The conflict between public interest and self-interest in public accounting’, *International Journal of Services and Standards*, Vol. 10, No. 3, pp.103–115.

- Long, W.F. and Ravenscraft, D.J. (1993) 'LBOs, debt and R&D intensity', *Strategic Management Journal*, Vol. 14, pp.119–136.
- Luo, T., Zhu, Q. and Li, D. (2009) 'The value relevance of R&D expenditure in Chinese public companies', *Journal of Financial Research*, Vol. 38, No. 6, pp.100–110.
- Mayers, D. and Smith Jr., C.W. (1982) 'On the corporate demand for insurance', *Journal of Business*, Vol. 55, pp.281–296.
- McConnell, J.J. and Servaes, H. (1990) 'Additional evidence on equity ownership and corporate value', *Journal of Financial Economics*, Vol. 27, pp.595–612.
- Min, B.S. and Verhoeven, P. (2013) 'Outsider board activity, ownership structure and firm value: evidence from Korea', *International Review of Finance*, Vol. 13, No. 2, pp.187–214.
- Morck, R., Shleifer, A. and Vishny, R.W. (1988) 'Management ownership and market valuation: An empirical analysis', *Journal of Financial Economics*, Vol. 20, pp.293–315.
- Moehrl, M.G. and Walter, L. (2008) 'Risk and uncertainty in R&D management', *R&D Management*, Vol. 38, No. 5, pp.449–451.
- Munari, F., Oriani, R. and Sobrero, M. (2010) 'The effects of owner identity and external governance systems on R&D investments: A study of Western European firms', *Research Policy*, Vol. 39, No. 8, pp.1093–1104.
- Nekhili, M., Boubaker, S. and Lakhil, F. (2012) 'Ownership structure, voluntary R&D disclosure and market value of firms: the French case', *International Journal of Business*, Vol. 17, No. 2, pp.126–140.
- O'Sullivan, N. (1997) 'Insuring the agents: the role of directors' and officers' insurance in corporate governance', *The Journal of Risk and Insurance*, Vol. 64, pp.545–556.
- O'Sullivan, N. (2002) 'The demand for directors' and officers' insurance by large UK companies', *European Management Journal*, Vol. 20, pp.574–583.
- Ortiz, D.A.C., Lau, W.K. and Qin, H. (2013) 'Quantitative analysis of impacts of employee engagement on continuance and normative commitment', *International Journal of Services and Standards*, Vol. 8, No. 4, pp.315–331.
- Pérez-gonzález, F. and Yun, H. (2013) 'Risk management and firm value: evidence from weather derivatives', *The Journal of Finance*, Vol. 68, No. 5, pp.2143–2176
- Giráldez, P. and Hurtado, J.M. (2014) 'Do independent directors protect shareholder value?', *Business Ethics: A European Review*, Vol. 23, No. 1, January, pp.91–107.
- Pindado, J., Queiroz, V.D. and Torre, C.D.L. (2015) 'How do country-level governance characteristics impact the relationship between R&D and firm value?', *R&D Management*, Vol. 45, No. 5, pp.515–526.
- Richardson, S.A. (2006) 'Over-investment of free cash flow', *Review of Accounting Studies*, Vol. 11, pp.159–189.
- Romano, R. (1991) 'The shareholder suit: litigation without foundation?', *The Journal of Law, Economics and Organization*, Vol. 7, pp.55–87.
- Szewczyk, S., Tsetsekos, G. and Zantout, Z. (1996) 'The valuation of corporate R&D expenditures: evidence from investment opportunities and free cash flow', *Financial Management*, Vol. 25, pp.105–110.
- Tassey, G. (1983) 'The induce versus purchase decision: an empirical analysis of industrial R&D', *Decision Sciences*, Vol. 14, pp.46–61.
- Yermack, D. (1996) 'Higher market valuation of companies with a small board of directors', *Journal of Financial Economics*, Vol. 40, pp.185–211.
- Zou, H., Wong, S., Shum, C., Xiong, J. and Yan, J. (2008) 'Controlling-minority shareholder incentive conflicts and directors' and officers' liability insurance: evidence from China', *Journal of Banking and Finance*, Vol. 32, pp.2636–2645.