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Managerial incentives and R&D investments: The moderating effect of the directors' and officers' liability insurance

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ABSTRACT

Literature regarding the impact of managerial incentives on firm's research and development (R&D) investments suggests that due to the riskiness of R&D activities, firms need to provide managerial incentives to encourage managerial discretion on corporate long-term investments of R&D. In spite that managerial incentives influence corporate R&D spending, some also argue corporate R&D spending a function of managerial incentive schemes. This paper applies the simultaneous equation to investigate the association between managerial discretion on R&D investments and the incentive scheme of CEO compensations by using the sample firms listed in Taiwan Security Exchange and Taipei Exchange. The results indicate that the listed firms in Taiwan simultaneously determine corporate R&D investments and CEO compensations. They reward their CEOs in compliance with their efforts on R&D investments and CEO compensation motivates CEOs to align their interests with firms' long-term investments on R&D. A further analysis of the protection effect from the directors' and officers' (D&O) liability insurance suggests that D&O protection intensifies the relationship between R&D investments and CEO compensation. It encourages CEOs to allocate resources on R&D activities and make CEO incentive contracts efficacious on corporate long-term investments. The result is robust in the electronic industry of Taiwan.

1. Introduction

Literature regarding determinants of corporate R&D spending focuses on the agency problems of managerial myopia where managers trade off corporate long-term value for the short-term earnings (Bushee, 1998; Chen, Lin, & Yang, 2015; Cheng, 2004). The two-edged prescriptions to the agency problems include the corporate governance mechanisms which deter managerial myopia on R&D spending and the managerial incentives which motivate managerial discretion on R&D investments.

External governance to facilitate R&D investments comes from the control market and institutional investors. However, the managerial myopia due to the pressures from the active takeover market (Shleifer & Vishny, 1989; Stein, 1988) as well as the quiet life which the managers harbor under the protection of takeover provisions (Becker-Blease, 2011) brings negative

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effects on corporate R&D investments. Institutional investors also play confounding roles in monitoring corporate R&D spending. Transient institutional investors cause managerial myopia on R&D investments (Bushee, 1998; Chen, Lin, & Yang, 2015; Dikolli, Kulp, & Sedatole, 2009). Thus, the monitoring effect from external governance seems limited (Chung & Wang, 2014).

Except for the monitoring mechanisms of managerial efforts on R&D, literature on the determinants of R&D suggests that managerial incentives encourage R&D investments (Cheng, 2004; Lin, Lin, Song, & Li, 2011; Tsao, Lin, & Chen, 2015). Cheng's (2004) study on *Forbes 500* firms found that changes in compensation could deter managerial myopia in R&D spending. Lin, Lin, Song, and Li (2011) indicated that CEO incentive schemes increase corporate innovation effort and performance in Chinese private sector. However, if the firms' incentive compensation aligns managerial interests with the firms' long-term investments such as R&D, the investment decision will also be influenced by the incentive schemes. Ryan and Wiggins (2002) posited that corporate R&D investment decisions and compensation policy are simultaneously determined. So, the first purpose of this paper is to conduct simultaneous equations to examine whether CEO compensation motivates corporate R&D investments by using the sample firms of an emerging market, Taiwan.

Since R&D activities are risky and costly, the extent to which CEOs devote to R&D activities depends on how the firms motivate their CEOs so as to align their interests with the firm's long-term goals. Manolopoulos (2006) survey found that economic compensation motivates R&D professionals in Greece most. Ryan and Wiggins (2002) separated the types of equity compensation into options and restricted stock. They found that restricted stock exerts a negative influence on R&D, but the nonlinear feature of options motivates risk-taking behavior. Moreover, Core (1997) and Aguir, Burns, Mansi, and Wald (2014) regarded directors' and officers' liability insurance as part of managerial incentive schemes and hypothesized that directors' (and officers') liability insurance would impact on director (officer) compensation. The mechanisms of compensation schemes and liability insurance could substitute for each other, implying that directors (officers) require greater compensation if they face less protection from corporate directors' and officers' (D&O) liability insurance. However, only the sample firms from the US supported the hypothesis (Aguir et al., 2014). As such, the second purpose of this paper is to investigate whether D&O liability insurance in Taiwan moderates the relationship between R&D spending and CEO compensation.

This paper focuses on the listed firms of the Taiwan Stock Exchange (TWSE) and Taipei Exchange between 2008 and 2013. The reasons to select Taiwan to study the research question are the encouraging environment of industrial innovation and corporate governance. Taiwan has been one of the "Asia Four Dragons" and experienced rapid growth due to its R&D efforts and performance. Under the guidance of *Statute for Industrial Innovation*, the government of Taiwan encourages corporate investing in R&D. Moreover, according to *Corporate Governance Best Practice Principles for TWSE/GTSM Listed Companies*, the listed firms are suggested to purchase the directors' and officers' (D&O) liability insurance so as to reduce the risk associated with the possible faults caused by business decisions. Both reasons make Taiwan an ideal template to study the relationship between R&D, CEO compensation and D&O liability insurance.

The empirical results prove that the listed firms in Taiwan simultaneously determine their R&D investment and compensation policy. The determinants of CEO compensation include R&D spending, market-to-book ratio, firm size, CEO tenure and firms' operating cash flows. On the other side, CEO compensation and tenure have positive relations with R&D investments. Overall, the evidences support our hypothesis that as CEOs devote to corporate R&D activities, they will be rewarded with a higher level of CEO compensation. Simultaneously, a higher level of CEO compensation motivates CEOs to align their interests with firms' long-term investments on R&D.

Further analysis indicates that D&O liability insurance in Taiwan positively moderates the relationship between R&D investments and CEO compensation, implying that CEOs in Taiwan regard D&O liability insurance as a complement to their compensation. This result contradicts with the substitute role of D&O liability insurance in the US (Aguir et al., 2014). Two behavioral theories might explain the complementary role of D&O liability insurance. Firstly, most companies reward their CEOs with high level of compensations. Higher level of compensations makes CEOs more loss-averse. So, CEOs with higher level of compensations require higher level of D&O protection to accept risky and uncertain R&D investments. Secondly, CEOs separate their compensations and insurance protection into two different mental accounts. The compensation schemes reward to their efforts and performance; while the liability insurance protects them from the possible loss associated with their duties.

The paper has the following structure: Section 2 reviews literature and develops hypotheses. Section 3 designs the research. Section 4 presents empirical results. Section 5 concludes this paper.

2. Literature review and hypothesis development

2.1. CEO compensation and R&D investments

R&D investing is one of the essential corporate decisions made by top managers of firms (Barker & Mueller, 2002). It seems that corporate takeovers by the control markets discipline managers to act in the best interests of the shareholders (Grossman & Hart, 1980). However, an active takeover market may cause managerial myopia where managers fear of undervaluation of their firms and focus more on short-term profits than long-term value (Shleifer & Vishny, 1989; Stein, 1988). Even with the presence of takeover provisions, the quiet life hypothesis predicts that managers exploit the provision protection to reduce their managerial efforts into risky projects such as R&D (Becker-Blease, 2011). The monitoring effect from

external governance to encourage R&D activities seems limited. Except for the monitoring mechanisms of managerial efforts on R&D, literature on the determinants of R&D suggests that managerial incentives encourage R&D investments (Cheng, 2004; Lin et al., 2011; Tsao, Lin, & Chen, 2015).

Balkin, Markman, and Gomez-Mejia (2000) posited that for the 90 high-technology sample firms in *Forbes*, CEOs' pay depends on their capability to innovate. Due to high riskiness and uncertainty of R&D activities, CEOs are rewarded for taking risks. Cheng's (2004) study on *Forbes 500* firms found that changes in compensation could deter managerial myopia in R&D spending. The evidences from an emerging market, Taiwan also indicated that firms in R&D intensive industries reward CEOs with cash or equity compensation for investing in innovation (Tsao et al., 2015). All proved that CEOs' efforts on R&D is one of the major determinants of CEO compensations.

As focusing on the determinants of R&D investments, Lin et al. (2011) examined the roles of managerial incentives in the firms' innovation activities of China's private sector and found that CEO incentive schemes increase corporate innovation effort and performance. Coles, Daniel, and Naveen (2006) proposed that higher sensitivity of CEO compensation scheme to stock return volatility (vega) provides CEOs incentives to implement relatively more investment in R&D. A further analysis on the relations between CEO compensation and R&D spending suggested that if the firms' incentive compensation aligns managerial interests with the firms' long-term investments such as R&D, the investment decision will also be influenced by the incentive schemes (Ryan & Wiggins, 2002). Thus, corporate investing choices and the managerial compensation scheme are jointly determined, implying that the endogeneity of these two choices exists (Coles et al., 2006; Ryan & Wiggins, 2002). Based on the literature of the determinants of CEO compensation and R&D investments, this paper expects a causal relationship between CEO compensation and R&D investments and suggests the following hypotheses.

H1: The listed firms in Taiwan regard CEO compensation structure and the R&D investment decision as endogenous choices.

H1a: The listed firms in Taiwan reward their CEOs in compliance with their efforts on R&D investments.

H1b: CEO compensation motivates CEOs to align their interests with firms' long-term investments on R&D.

2.2. Directors' and officers' (D&O) liability insurance

In Taiwan, the *Corporate Governance Best Practice Principles for TWSE/GTSM Listed Companies* suggest that the listed firms purchase the directors' and officers' (D&O) liability insurance so as to reduce the risk associated with the possible faults caused by the directors. In the context of how D&O insurance impacts on the corporate investment decisions, the monitoring hypothesis posits that D&O insurance helps align the directors' and officers' interests with the shareholders'; while the empirical results from Taiwan (Li & Liao, 2014) support the opportunism hypothesis where firms whose managers are protected under higher D&O insurance coverage are more likely to commit more resources to over investing. As the insurance coverage moves closer to full insurance, the directors become less risk averse and less likely to reject attractive new risky projects (Core, 1997).

Core (1997) suggested that D&O insurance is a part of an outside director's compensation package and if the package does not meet his or her reservation utility, they will require other forms of compensation as risk premium. So, D&O insurance substitutes for the director's compensation. However, Core's (1997) empirical results from Canadian firms did not support the substation role of D&O. Aguir et al. (2014) also argued that directors (officers) prefer to work for companies providing more protection and require greater compensation if they face less protection from corporate D&O liability insurance. The evidences from the U.S. companies supported that the director compensation and D&O protection substitute for each other.

Based on the above arguments, though D&O insurance might encourage CEO risk-taking, a higher level of D&O coverage also compensates for CEOs' reservation utility and further weakens the relationship between CEO compensation and CEO risk-taking activities, R&D investments. Thus, this paper suggests the second hypothesis as following.

H2: D&O liability insurance in Taiwan moderates the relationship between R&D investments and CEO compensation.

3. The data and empirical models

3.1. The data

This paper adopts sample firms listed in Taiwan Stock Exchange and Taipei Exchange and collects all the firm-year variables from TEJ (Taiwan Economic Journal) database. The sample period starts from 2008 to 2013 as Taiwan Stock Exchange claims the listed firms to disclose whether to purchase D&O liability insurance since 2008. The final sample consists of 4436 firm-year observations from 772 unique firms between 2008 and 2013.

3.2. The empirical models

As discussed above, firms may simultaneously determine their R&D investment and CEO compensation. This paper estimates their interdependence in the context of a structural simultaneous equation model as follows

$$R\&D = f_1(COMP;\ COMP \times D\&O,\ Control_1) + \in_1 \quad (1)$$

$$COMP = f_2(R\&D;\ Control_2) + \in_2 \quad (2)$$

here *R&D*, *COMP* and *D&O* denote the R&D investment decision, CEO compensation and D&O liability insurance policies, respectively. $Control_1$ and $Control_2$ are vectors of exogenous controlling variables in R&D and CEO compensation equations. The interaction of D&O liability insurance and CEO compensation ($COMP \times D\&O$) captures the moderating effect on the relationship between R&D spending and CEO compensation.

Since the regressors are endogenously determined along with dependent variable, the application of OLS estimation yields biased and inconsistent estimates. To control for the possible endogenous problems among these two decisions, this study applies two-stage least squares (2SLS) method to estimate the simultaneous equation model. In fitting these equations by 2SLS, the instrumental variable estimate of "*COMP*" in Eq. (1) is taken from regressing compensation on all exogenous variables of the compensation Eq. (2). Likewise, the instrumental variable estimate of "*R&D*" in Eq. (2) is obtained from regressing R&D on all exogenous variables of the R&D Eq. (1).

3.3. The definitions of variables

3.3.1. Endogenous variables

There are two endogenous variables in our simultaneous equation model. One is the R&D intensity measured as the ratio of R&D expenditures to total firm assets. The other one is the chief executive officer (CEO) compensation calculated as the log of one plus total compensation, measured as the sum of equity-based and cash-based compensations. The cash-based compensation includes base salary, pension, bonus, special fees and cash dividend.

3.3.2. Moderating variable

This paper uses two proxies as the moderating variable. First, a dummy variable equals one if the firms purchase D&O liability insurance for their CEOs and zero otherwise. The other one is the D&O liability coverage, which equals the proportion of the amount of firm's D&O coverage to the total assets of the firm.

3.3.3. Control variables

To avoid the possibility of model misspecification, this paper controls for additional variables in R&D investment decision and CEO compensation policy that appear regularly in the literature (e.g. Ryan & Wiggins, 2002). Here, the control variables in Eq. (1) of R&D investment decision ($Control_1$) include lagged R&D intensity, CEO stock ownership, institutional ownership, firm's growth opportunity, firm's leverage, firm size, CEO tenure, free cash flow and firm's market share. In CEO compensation equation, vector of $Control_2$ includes the lagged compensation, CEO ownership, market to book ratio, firm leverage, firm size, CEO tenure, square of CEO tenure, operating cash flow, market share, board independence, board ownership, CEO duality and family dummy.

The definition of the control variables describes as follows. CEO stockownership equals the division of CEO stock holdings by the total shares outstanding. The institutional ownership results from summation of institutional ownership in Taiwan, including foreign institutional ownership, mutual funds ownership and proprietary traders' ownership. The division of equity book value by its market value captures the firm's growth opportunity. The division of total debts by total assets captures the firm's leverage. Firm size equals to the natural logarithm of total assets. The scaled firm's operating cash flows are the division of the firm's operating cash flows by total assets. The division of firm's sales by the total sales of the industry captures the firm's market share. CEO tenure is measured as the number of years of CEO experience in the position. To test for the curvilinear relationship between CEO tenure and R&D spending as well as compensation policy, this paper also includes the square term of CEO tenure. Taiwan defines corporate shareholders whose stock ownership exceeds 5% as the block holders and calculates block ownership as the summation of the block holders' ownership. The board independence is the ratio of independent directors to total board directors. An indicator variable equals one if the firm's CEO also serves as the chairman and zero otherwise. Taiwan Economic Journal (TEJ) defines the family businesses as those controlled by one single family group. This paper identifies a firm as a family business if TEJ classifies it as a family business and assigns an indicator variable equal to one to proxy for family business.

4. Empirical results

4.1. Preliminary statistics

Table 1 provides the summary statistics of the dependent, independent, moderating and control variables included in the simultaneous equations. Panel A summarizes the means, median and standard deviation of the variables. The data in Taiwan from 2008 to 2013 indicates that the average R&D intensity is 2.286%, which is lower than that in the US (4%) from 1992 to 2002 (Coles et al., 2006). However, the average CEO compensation in our sample almost equals to 4021 thousands NT dollars (i.e. 130 thousands US dollars), which is far below the US cash compensation level (1140 thousands US dollars) from 1992 to 2002 (Coles et al., 2006). The preliminary statistics imply that R&D gap between Taiwan and the US is relatively less in comparison with the disparity of CEO compensations.

Table 1
Summary statistics.

	Mean	Median	Standard Deviation
Panel A. Mean, Median and Standard Deviation of Variables			
R&D Expenses/Total Assets (%)	2.286	0.842	4.262
CEO Compensation (in Thousand Dollars)	4021.743	2967.387	4187.355
CEO Stock Ownership (%)	2.444	0.540	4.163
Institutional Ownership (%)	11.214	6.040	13.739
Book to Market Ratio	1.566	1.160	3.347
Firm Leverage	43.062	43.251	18.385
Firm Size	15.861	15.734	1.489
CEO Tenure	8.662	5.583	8.745
Operating Cash Flow	0.062	0.064	0.115
Market Share (%)	2.359	0.219	7.588
Board Independence	0.095	0.000	0.125
Block Ownership (%)	20.883	18.725	12.061
CEO Duality	0.293	0.000	0.455
Family Business	0.658	1.000	0.474
Sample size	4366		
	D&O = 1	D&O = 0	Difference in Mean
Panel B. Means of Main Variables in D&O Insurance Purchasing and Non-purchasing Firms			
R&D Expenses/Total Assets(%)	3.150	1.304	1.847*** (14.63)
CEO Compensation (in Thousand Dollars)	4787.818	3151.475	1636.343*** (13.14)
CEO Stock Ownership (%)	2.092	2.843	−0.750*** (−5.97)
Institutional Ownership (%)	13.316	8.827	4.489*** (10.92)
Book to Market Ratio	1.708	1.404	0.305** (3.01)
Firm Leverage	43.239	42.861	0.378 (0.68)
Firm Size	16.016	15.685	0.331*** (7.38)
CEO Tenure	7.895	9.534	−1.639*** (−6.21)
Operating Cash Flow	0.069	0.054	0.016*** (4.49)
Market Share (%)	1.960	2.812	−0.852*** (−3.71)
Board Independence	0.136	0.049	0.087*** (24.46)
Block Ownership (%)	19.263	22.723	−3.459 (−9.55)
CEO Duality	0.290	0.297	−0.007 (−0.52)
Family Business	0.564	0.765	−0.201*** (−14.28)
Sample size	2322	2044	

Note: D&O is a dummy variable for the purchase of D&O which equals to one if the firm purchased the D&O liability insurance and zero otherwise. *t* statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Panel B of Table 1 provides the difference in mean of the variables between D&O insurance purchasing and non-purchasing firms. The data indicates that for the D&O purchasing firms, the variables of R&D intensity, CEO compensation, institutional ownership, growth opportunity measured by book-to-market ratio, firm size, operating cash flow, and board independence are statistically greater than those of the non-purchasing firms. Firms which purchase the D&O liability insurance also allocate more resources on R&D activities and pay higher CEO compensations.

Table 2
Pearson's correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) R&D/Total Assets	1									
(2) CEO Compensation	0.07***	1								
(3) CEO Stock Ownership	0.08***	−0.10***	1							
(4) Institutional Ownership	0.02	0.38***	−0.12***	1						
(5) Book to Market Ratio	0.06***	−0.01	−0.01	0.09***	1					
(6) Firm Leverage	−0.19***	−0.04***	−0.07***	0.02	0.06***	1				
(7) Firm Size	−0.19***	0.45***	−0.22***	0.52***	−0.12***	0.25***	1			
(8) CEO Tenure	−0.01	0.12***	0.30***	0.02	−0.04***	−0.06***	0.01	1		
(9) Operating Cash Flow	−0.08***	0.25***	−0.02	0.21***	−0.12***	−0.24***	0.20***	0.10***	1	
(10) Market Share	−0.12***	0.16***	−0.10***	0.21***	−0.00	0.15***	0.46***	−0.01	0.03*	1

** $p < 0.05$.
* $p < 0.10$.
*** $p < 0.01$.

Table 2 presents the Pearson's correlation matrix of the variables involved. The R&D intensity is positively related to CEO compensation, CEO ownership and firm's growth opportunity. CEO compensation is positively related to the institutional ownership, firm size, CEO tenure, firm's operating cash flow and the market share.

4.2. The Determinants of R&D and CEO compensation

Corporate R&D investments are likely to be determined by CEO compensation. However, one may argue that CEOs are rewarded based on their contributions to corporate R&D activities. To alleviate the potential concerns of the endogenous problem, this paper estimates the relationship between R&D and CEO compensation by constructing a simultaneous equation model.

A two-stage least square (2SLS) method is applied to estimate the parameters of the simultaneous equation model. The spirit of 2SLS estimation is to deal with the endogenous regressor by instrumental variables. We use all the exogenous variables in this system as our instrumental variables which are supported by the extant literature. Here, we regress each endogenous regressor on all exogenous variables in the system and obtain the prediction of endogenous regressor and Shea (1997)'s partial R-square as well as first-stage F-statistics, which are statistically significant to support the strength of the instrumental variables used here.

Table 3 examines the determinants of corporate R&D investments and CEO compensation. The compensation equation that analyzes the determinants of CEO compensation shows a positive relation with R&D, which confirms our hypothesis that the listed firms in Taiwan reward their CEOs in compliance with their efforts on R&D investments. The result is

Table 3
Results of 2SLS estimation of R&D determinants and CEO compensation policy.

R&D (Scaled by Total Assets)		CEO Compensation (in Natural Log Form)	
Compensation	0.086***	R&D	0.007***
	(2.93)		(2.97)
Lagged R&D	0.908***	Lagged Compensation	0.672***
	(151.44)		(62.14)
CEO Ownership	0.006	CEO Ownership	−0.001
	(1.03)		(−0.42)
Institutional Ownership	0.002	Market to Book Ratio	0.009***
	(1.18)		(3.59)
Market to Book ratio	−0.000	Firm Leverage	−0.001*
	(−0.02)		(−1.93)
Firm Leverage	−0.004***	Firm Size	0.088***
	(−3.02)		(11.25)
Firm Size	−0.032	CEO Tenure	0.006**
	(−1.41)		(2.06)
CEO Tenure	0.018**	Square of CEO Tenure	−0.000
	(2.46)		(−0.50)
Square of CEO Tenure	−0.001***	Operating Cash Flow	0.420***
	(−2.68)		(5.15)
Operating Cash Flow	−0.776***	Market Share	0.001
	(−3.59)		(0.52)
Market Share	0.003	Board Independence	0.026
	(0.77)		(0.34)
		Board Ownership	−0.001
			(−1.63)
		CEO Duality	−0.051**
			(−2.44)
		Family	−0.042**
			(−2.23)
Constant	−0.086	Constant	1.245***
	(−0.24)		(9.79)
Year Effects	YES	Year Effects	YES
Industry Effects	YES	Industry Effects	YES
N	4366		4366
adj. R^2	0.883		0.639

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

consistent with those of Ryan and Wiggins (2002) in the American case, Lin et al. (2011) in the Chinese private sector and Tsao et al. (2015) in Taiwanese R&D-intensive industries.

As expected, the market-to-book ratio, firm size and operating cash flow have positive relations with CEO compensation. Moreover, CEO tenure is also positively associated with CEO compensation. This result contradicts with that of Ryan and Wiggins (2002), indicating a negative relation between CEO compensation and tenure. Ryan and Wiggins (2002) suggested that CEOs who have stayed in their positions for a long time would possess larger human capital investments, so the firms reward them less; while this paper finds that in Taiwan, it costs the listed firms a lot to train CEOs and the listed firms reward higher compensations to the more experienced CEOs. The negative relations with CEO duality and family firm indicator indicate that the agency problems where CEOs reward themselves much more due to duality or power centralization of family business do not exist in Taiwan.

The R&D equation in Table 3 estimates the determinants of corporate R&D investments. The positive relation between R&D intensity and CEO compensation supports the hypothesis that CEO compensation motivates CEOs to align their interests with firms' long-term investments on R&D. The finding is consistent with that of Ryan and Wiggins (2002) in the American case and Lin et al. (2011) in Chinese private sector.

The effect of CEO tenure on R&D intensity is positive and significant; while the effect of the CEO tenure-squared term is negative, implying that the effects of CEO tenure on R&D intensity appear to be inverted U-shaped. This finding suggests that in Taiwan, the experienced CEOs are more competent to allocate firms' resources to R&D. However, in their later seasons, CEOs may myopically commit to obsolete paradigms and become risk-averse (Levinthal & March, 1993; Luo, Kanuri, & Andrews, 2014; Miller, 1991) and thus devote less on R&D. The very fresh CEOs also have the incentives to focus on

Table 4
Results of D&O insurance moderating effects.

	R&D (Scaled by Total Assets)	
Lagged R&D	0.907***	0.907***
	(150.36)	(150.70)
CEO Compensation	0.082***	0.080***
	(2.82)	(2.69)
CEO Ownership	0.007	0.006
	(1.16)	(1.10)
Institutional Ownership	0.002	0.002
	(1.11)	(1.13)
Market to Book Ratio	−0.003	−0.000
	(−0.46)	(−0.06)
Firm Leverage	−0.004***	−0.004***
	(−3.08)	(−3.07)
Firm Size	−0.022	−0.034
	(−0.96)	(−1.48)
CEO Tenure	0.019**	0.019**
	(2.55)	(2.53)
Square of CEO Tenure	−0.001***	−0.001***
	(−2.75)	(−2.72)
Operating Cash Flow	−0.733***	−0.780***
	(−3.37)	(−3.61)
Market Share	0.002	0.003
	(0.63)	(0.79)
CEO Compensation × D&O Coverage	4.06×10^{-4} *	
	(1.81)	
CEO Compensation × D&O Dummy		0.007
		(1.07)
Constant	−0.230	−0.041
	(−0.63)	(−0.12)
Year Effects	YES	YES
Industry Effects	YES	YES
N	4366	4366
adj. R^2	0.883	0.883

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

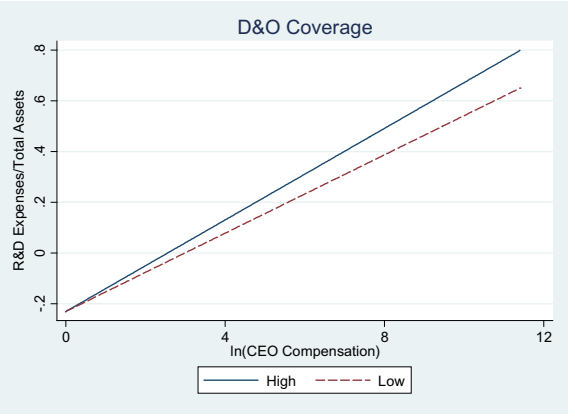
short-term outcomes in order to build their reputations (Hirshleifer, 1993), so they allocate relatively less on R&D in their early tenure seasons.

4.3. The moderating effect of directors' and officers' (D&O) liability insurance

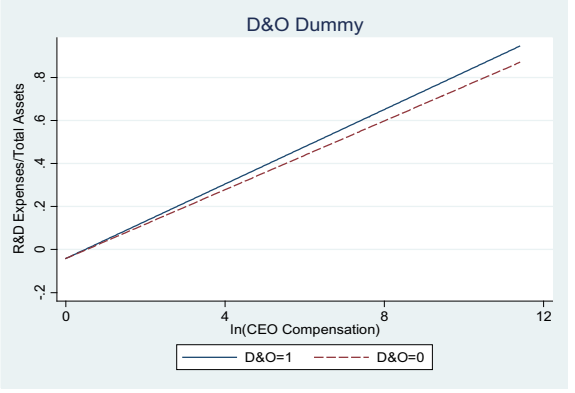
To investigate the moderating effect of D&O protection, this paper uses a D&O dummy and the amount of D&O insurance coverage to proxy for the D&O protection and adds the interaction terms of CEO compensation × D&O coverage and CEO compensation × D&O dummy separately to the R&D equation.

Table 4 analyzes the moderating effect of D&O liability protection on the relationship between R&D investments and CEO compensation. The estimated signs of CEO compensation and the control variables in Table 4 are the same as those estimated in the R&D equation of Table 3. The coefficient of interaction term (CEO compensation × D&O coverage) is significantly positive, indicating that D&O protection intensifies the relationship between R&D investments and CEO compensation. Fig. 1 further illustrates that CEO incentive schemes have more impacts on R&D investments for the firms with relatively greater D&O protection. As the firms increase their CEO compensations, R&D investments increase more for the firms with relatively higher D&O insurance coverage than those whose D&O insurance coverage are relatively less. The coefficient of interaction term, CEO compensation × D&O dummy, is also positive, but not statistically significant. Panel B of Fig. 1 demonstrates similar scenario with that of Panel A of Fig. 1. The result confirms the hypothesis that D&O liability insurance in Taiwan moderates the relationship between R&D investments and CEO compensation.

However, the result contradicts with the US evidence that D&O liability insurance can substitute for CEO compensation in US (Aguir et al., 2014). Two behavioral theories might explain the complementary role of D&O liability insurance. First, CEOs are rewarded with high level of compensations as they allocate large resources on corporate R&D activities. However, CEOs become more loss-averse as they are highly paid and require higher level of D&O protection to accept risky and uncertain R&D investments. Secondly, CEOs separate their compensations and insurance protection into two different mental accounts. The compensation schemes reward to their efforts and performance; while the liability insurance protects them from the possible loss associated with their duties.



Panel A. The D&O Insurance Coverage



Panel B. The Purchase of D&O Insurance

Fig. 1. Moderating effect of D&O insurance policy on the relationship between R&D investment decision and CEO compensation policy.

Table 5
Results of compensation types on R&D.

	R&D (Scaled by Total Assets)		
Lagged R&D	0.906***	0.904***	0.906***
	(150.60)	(149.90)	(150.10)
EBC Compensation	0.085***	0.028	0.170
	(2.65)	(0.61)	(1.14)
CBC Compensation	0.173***	0.165***	0.171***
	(4.14)	(3.93)	(3.95)
CEO Ownership	0.007	0.008	0.007
	(1.12)	(1.38)	(1.14)
Institutional Ownership	0.001	0.001	0.001
	(0.59)	(0.64)	(0.62)
Market to Book Ratio	−0.002	−0.005	−0.002
	(−0.31)	(−0.64)	(−0.34)
Firm Leverage	−0.004***	−0.004***	−0.004***
	(−2.72)	(−2.74)	(−2.69)
Firm Size	−0.061**	−0.043*	−0.062**
	(−2.52)	(−1.72)	(−2.57)
CEO Tenure	0.016**	0.015**	0.016**
	(2.14)	(2.10)	(2.19)
Square of CEO Tenure	−0.001**	−0.001**	−0.001**
	(−2.46)	(−2.44)	(−2.49)
Operating Cash Flow	−0.907***	−0.903***	−0.908***
	(−4.15)	(−4.12)	(−4.16)
Market Share	0.003	0.003	0.003
	(0.91)	(0.69)	(0.92)
EBC × D&O Coverage		0.023***	
		(2.96)	
EBC × D&O Coverage		0.000	
		(1.46)	
EBC × D&O Dummy			−0.093
			(−0.63)
CBC × D&O Dummy			0.003
			(0.40)
Constant	−0.289	−0.508	−0.265
	(−0.76)	(−1.30)	(−0.69)
Year Effects	YES	YES	YES
Industry Effects	YES	YES	YES
N	4366	4366	4366
adj. R^2	0.883	0.884	0.883

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 5 separates CEO compensations into two categories, the equity-based compensation (EBC) and the cash-based compensation (CBC) and investigates which type of CEO compensations motivates corporate R&D spending. The empirical results from the 1st column indicate that both EBC and CBC are positively related to corporate R&D investing, implying that in Taiwan, the cash as well as the stocks are of equal importance to motivate CEOs' spending on corporate R&D. However, D&O moderating effects on the relationship between equity-base compensation and corporate R&D disappear. The coefficient of the interaction term (CBC × D&O coverage) implies a positive direction where D&O coverage may intensifies the relationship between R&D and CEO cash-based compensation.

4.4. The determinants of R&D and CEO compensation by industries

R&D investment is a crucial to the firm's innovation activities (Tsao et al., 2015). Balkin et al. (2000) found that the impact of CEO compensation on R&D investment for high-technology (i.e., R&D-intensive) firms is different from that for low-technology firms. The positive relationship between CEO compensation and R&D investment exists only for high-technology firms.

This paper further investigates whether the relationship between CEO compensation and R&D investment varies with the industries. We divide our sample into two sub samples, the electronic and the non-electronic industries and run the simultaneous equation of Model (1) and (2). Table 6 provides robust results on the electronic industry, indicating that corporate R&D investments and CEO compensation are simultaneously determined, which is consistent with the finding of Balkin et al. (2000). However, we do not find the consistent results on the non-electronic industry.

Table 6
Results of 2SLS estimation of R&D determinants and CEO compensation Policy classified by industries.

R&D (Scaled by Total Assets)			CEO Compensation (in Natural Log Form)		
	Electronic	Non-electronic		Electronic	Non-electronic
Compensation	0.398***	0.006	R&D	0.579***	0.773***
	(4.21)	(0.26)		(37.58)	(52.36)
Lagged R&D	0.901***	0.962***	Lagged Compensation	0.010***	0.004
	(103.89)	(121.93)		(3.69)	(0.52)
CEO Ownership	0.017	0.006*	CEO Ownership	−0.006*	0.000
	(1.45)	(1.89)		(−1.66)	(0.12)
Institutional Ownership	0.004	−0.000	Market to Book Ratio	0.021**	0.008***
	(1.17)	(−0.30)		(2.56)	(2.85)
Market to Book ratio	0.005	0.003	Firm Leverage	−0.002**	−0.001
	(0.15)	(0.90)		(−2.11)	(−0.76)
Firm Leverage	−0.009***	0.001	Firm Size	0.111***	0.058***
	(−3.11)	(1.48)		(10.07)	(4.82)
Firm Size	−0.105**	0.006	CEO Tenure	0.007*	0.005
	(−2.20)	(0.37)		(1.65)	(1.25)
CEO Tenure	0.030**	0.010**	Square of CEO Tenure	−0.000	−0.000
	(1.96)	(2.35)		(−0.53)	(−0.47)
Square of CEO Tenure	−0.001**	−0.000**	Operating Cash Flow	0.547***	0.297***
	(−2.40)	(−2.18)		(4.68)	(2.64)
Operating Cash Flow	−2.192***	0.380***	Market Share	0.025**	0.000
	(−5.26)	(2.87)		(2.16)	(0.32)
Market Share	−0.028	−0.000	Board Independence	−0.025	0.095
	(−0.68)	(−0.17)		(−0.26)	(0.77)
			Board Ownership	0.001	−0.002**
				(0.61)	(−2.33)
			CEO Duality	−0.042	−0.030
				(−1.44)	(−1.02)
			Family	−0.028	−0.067**
				(−1.11)	(−2.39)
Constant	−1.051	−0.241	Constant	1.645***	0.864***
	(−1.40)	(−1.06)		(9.61)	(4.53)
Year Effects	YES		Year Effects	YES	
Industry Effects	YES		Industry Effects	YES	
N	2166	2200		2166	2200
adj. R^2	0.863	0.879		0.612	0.669

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 7 analyzes D&O insurance moderating effects on the electronic firm's versus the non-electronic firm's R&D investments respectively. Again, we find a robust moderating effect on the electronic firms only, indicating that firms in the electronic industry use D&O insurance as the complements to motivate CEO spending on corporate R&D. Table 8 further divides the compensation types into the equity-based and cash-based compensation. We find that D&O insurance complements cash-based compensation only in the electronic industry. This supplements our results in Table 4, implying that CEOs in the electronic industry are motivated by the cash-based compensations to align their interests with firms' long-term investments on R&D. CEOs become more loss-averse as they are highly paid by cash and require higher level of D&O protection to accept risky and uncertain R&D investments.

5. Conclusion

This study investigates whether the incentive schemes encourages corporate R&D investments in an emerging market, Taiwan. Moreover, we explore whether D&O protection exacerbates CEO risk-taking activities by examining D&O liability insurance moderating effects on the relationship between CEO compensations and corporate R&D investments. The findings contribute to the literature in the following two aspects.

Table 7
Results of D&O insurance moderating effects by industries.

	R&D (Scaled by Total Assets)			
	Electronic	Non-Electronic	Electronic	Non-Electronic
Lagged R&D	0.897***	0.963***	0.902***	0.961***
	(101.90)	(121.84)	(103.58)	(121.11)
CEO Compensation	0.384***	0.007	0.401***	0.001
	(4.04)	(0.31)	(4.03)	(0.06)
CEO Ownership	0.020*	0.006*	0.017	0.007**
	(1.68)	(1.79)	(1.44)	(1.99)
Institutional Ownership	0.004	−0.000	0.005	−0.000
	(1.05)	(−0.25)	(1.18)	(−0.39)
Market to Book Ratio	−0.005	0.004	0.005	0.003
	(−0.18)	(1.21)	(0.16)	(0.84)
Firm Leverage	−0.009***	0.001	−0.008***	0.001
	(−3.18)	(1.52)	(−3.10)	(1.36)
Firm Size	−0.069	0.002	−0.104**	0.005
	(−1.39)	(0.12)	(−2.19)	(0.34)
CEO Tenure	0.032**	0.010**	0.030*	0.011**
	(2.10)	(2.29)	(1.96)	(2.48)
Square of CEO Tenure	−0.001**	−0.000**	−0.001**	−0.000**
	(−2.51)	(−2.14)	(−2.40)	(−2.28)
Operating Cash Flow	−1.994***	0.369***	−2.193***	0.369***
	(−4.72)	(2.78)	(−5.26)	(2.78)
Market Share	−0.039	−0.000	−0.028	−0.000
	(−0.94)	(−0.07)	(−0.68)	(−0.15)
COMP × D&O Coverage	0.002***	−0.000		
	(2.81)	(−1.27)		
COMP × D&O Dummy			−0.003	0.005
			(−0.23)	(1.50)
Constant	−1.531**	−0.192	−1.074	−0.216
	(−2.01)	(−0.83)	(-1.39)	(-0.94)
Year Effects	YES	YES	YES	YES
N	2166	2200	2166	2200
adj. R^2	0.864	0.879	0.863	0.879

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

First, recent literature (e.g. Ryan & Wiggins, 2002) proposed that firms may simultaneously determine their R&D investment and CEO compensation, so this paper applies two-stage least squares (2SLS) method to estimate the simultaneous equations of corporate R&D investments and CEO compensations in an emerging market, Taiwan. The results from the proposed model confirm our hypothesis that the listed firms in Taiwan simultaneously determine their incentive schemes and R&D investments. They reward their CEOs in compliance with their efforts on R&D investments and similarly, CEO compensation motivates CEOs to align their interests with firms' long-term investments on R&D.

Second, in Taiwan, the *Corporate Governance Best Practice Principles for TWSE/GTSM Listed Companies* suggest that the listed firms purchase the directors' and officers' (D&O) liability insurance so as to reduce the risk associated with the possible faults caused by the directors. This paper finds that D&O liability insurance in Taiwan positively moderates the relationship between R&D investments and CEO compensation. Though the moderating effect of D&O liability insurance supports the opportunism hypothesis of managerial risk-taking behavior (Li & Liao, 2014), it does encourage CEO to allocate resources on R&D activities and make CEO incentive contracts efficacious on corporate long-term investments.

Thirdly, this paper investigates whether the relationship between CEO compensation and R&D investment varies with the industries. We find robust results on the electronic industry, indicating that corporate R&D investments and CEO compensation are simultaneously determined, which is consistent with the finding of Balkin et al. (2000). In the electronic industry, D&O insurance also intensifies the relationship between CEO compensation and corporate R&D. As dividing CEO compensations into equity-based and cash-based ones, D&O insurance moderating effect appears only on the relationship between cash-based compensation and R&D investments, implying that CEOs become more loss-averse as they are highly paid by cash and require higher level of D&O protection to accept risky and uncertain R&D investments.

Table 8
Results of Compensation Types on R&D by Industries.

	R&D (Scaled by Total Assets)			
	Electronics	Non-Elect.	Electronics	Non-Elect.
Lagged R&D	0.896***	0.963***	0.902***	0.961***
	(101.96)	(121.71)	(103.62)	(121.02)
EBC Compensation	−0.049	−0.037	0.047	−0.053
	(−0.59)	(−0.68)	(0.16)	(−0.68)
CBC Compensation	0.356***	0.006	0.395***	0.001
	(3.77)	(0.28)	(3.96)	(0.03)
CEO Ownership	0.020*	0.006*	0.017	0.007**
	(1.69)	(1.81)	(1.46)	(2.00)
Institutional Ownership	0.004	−0.000	0.004	−0.000
	(1.06)	(−0.26)	(1.17)	(−0.39)
Market to Book Ratio	−0.002	0.004	0.002	0.003
	(−0.08)	(1.21)	(0.08)	(0.84)
Firm Leverage	−0.009***	0.001	−0.009***	0.001
	(−3.24)	(1.57)	(−3.11)	(1.40)
Firm Size	−0.058	0.003	−0.104**	0.006
	(−1.15)	(0.21)	(−2.14)	(0.40)
CEO Tenure	0.030**	0.010**	0.028*	0.011**
	(1.97)	(2.29)	(1.86)	(2.46)
Square of CEO Tenure	−0.001**	−0.000**	−0.001**	−0.000**
	(−2.40)	(−2.15)	(−2.29)	(−2.28)
Operating Cash Flow	−2.052***	0.367***	−2.232***	0.369***
	(−4.86)	(2.76)	(−5.36)	(2.78)
Market Share	0.004	−0.000	−0.039	−0.000
	(0.08)	(−0.14)	(−0.90)	(−0.20)
EBC × D&O Coverage	0.031**	0.015		
	(2.49)	(0.51)		
CBC × D&O Coverage	0.001**	−0.000		
	(2.57)	(−1.27)		
EBC × D&O Dummy			0.039	0.038
			(0.13)	(0.47)
CBC × D&O Dummy			−0.006	0.005
			(−0.38)	(1.47)
Constant	−1.477*	−0.210	−0.999	−0.226
	(−1.94)	(−0.91)	(−1.27)	(−0.99)
Year Effects	YES	YES	YES	YES
N	2166	2200	2166	2200
adj. R^2	0.864	0.879	0.863	0.879

t statistics in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

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