Impact of Managers' Traits and Compensation Structure on R&D Investments

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This study examines the relationships between the characteristics of top management and a firm's R&D expenditure level. We measure management entrenchment using executives' tenures, ages, cash compensation, and dual roles as a chairman. The result suggests that firms with less entrenched management (i.e., younger, newer, and non-chairman executives with less cash compensation) invest more in R&D. Our result also shows that executives whose compensation has a higher sensitivity to stock volatility are associated with higher degree of R&D expenditures implying that executives' compensation structures tend to influence R&D decisions.

INTRODUCTION

Research and development (R&D) investments are essential for businesses to stay competitive and innovative. Continuous innovation and improvement have become increasingly important especially in today's rapidly advancing digital economy. When well executed, R&D investments enable a firm to exploit tremendous growth opportunities and capitalize profits. While such potential benefits make it highly attractive, R&D is considered as a relatively risky investment option compared to other choices, such as investments in tangible or fixed assets (Coles, Daniel, and Naveen, 2006). Given the potential benefits and underlying risks, it requires corporate managers to carefully evaluate the investment choices. The decision process involves managers' discretion and judgment and the outcome can vary across managers depending on the individual differences in risk aversion. In this paper, we examine whether and how the risky nature of R&D expenditure encourages executives with different preferences and incentives to behave differently toward R&D strategies.

The literature suggests that specific characteristics and preferences of managers affect a firm's risk-taking policies such as R&D (Bertrand and Schoar, 2003) and M&A decisions (Li and Wang, 2018). The factors considered to influence firms' risk-taking policies include CEOs' gender (Croson and Gneezy, 2009; Faccio, Marchica, and Mura, 2016), age (Serfling, 2014; Chowdhury, 2017), duality role (Yang and Zhao, 2014; Baliga, Moyer, and Rao, 1996), and management entrenchment (Berger, Ofek and Yermack, 1997; Singh, 2015). In this study, we consider all of these factors and examine how they jointly impact managers' investment decisions in R&D. Specifically, which factors play more essential roles in determining a firm's R&D investment.

Faccio et al. (2016) document the association between female CEOs and corporations' risk avoiding choices. They argue that female CEOs are in general more risk averse than male counterparts and therefore prefer less risky investments. On the other hand, other studies show that banks with more female board members take more risk than banks with fewer female board members (Berger, Kick, and Schaeck, 2014). Kim, Roden, and Cox (2013) provide evidence of female directors' impact on improving the board's oversight function by dislodging potential entrenchment.

As for the relationship between CEOs' ages and R&D expenditure, recent studies (Serfling, 2014; Chowdhury, 2017) empirically provide evidence that older CEOs invest less in research and development. In the study of a contrasting result, Holmstrom (1999) argue that younger CEOs are more risk-averse because they are more concerned about and want to protect their future career and earnings opportunities. CEOs' ages and tenures are often used as measures of management entrenchment. Extant empirical findings document the relationship between management entrenchment and a firm's risk taking decisions. For instance, Berger et al. (1997) find that entrenched CEOs seek to avoid risky decisions, such as issuing debt, failing to maintain the value-maximizing debt level, resulting in sub-optimal capital structure. They characterize older managers with higher cash compensation to be more likely to be entrenched. Core, Holthausen, and Larcker (1999) find that the tenure of a CEO is associated with increased CEO influence on directors, implying entrenchment. Singh (2015) argues that firms with entrenched management tend to make myopic decisions, bear less risk, and invest less in R&D.

Activists and regulators have blamed CEO duality, by which CEO assumes the chairman position of the board of directors, for management entrenchment that is against healthy corporate governance (Yang and Zhao, 2014). Paradoxically, some shareholders and managers welcome the CEO duality with the belief that a CEO's experience with a firm and inside knowledge benefit the board of directors' oversight roles through efficient and speedy decisions. Empirical evidence is also mixed. For example, Yang and Zhao (2014) find that duality firms outperform non-duality firms when their competitive environments change. Baliga et al. (1996) report no significant performance differences between before and after changes in duality status.

Another body of literature, based on the agency problems, examines the impact of management incentives embedded in the compensation structures. Empirical studies (Coles et al. 2006; Nam, Ottoo, Thornton, 2003; Ryan and Wiggins, 2002) confirm that managers tend to take less risk than the optimal level when the compensation policy provides incentives to avoid risks, whereas Aggarwal and Samwick (2006) find conflicting evidence. Coles et al. (2006) provide evidence for the influence of executive compensation structure on a firm's policy. They find a positive association between the higher sensitivity of a CEO's stock option portfolio to stock returns volatility (referred to as Vega) and riskier policy choices, including higher R&D intensity. Nam et al. (2003) similarly conclude that as Vega increases, firms tend to make a higher level of R&D investment because the sensitivity of managers' wealth to stock return volatility give managers an incentive to take more risks.

The goal of this study is to answer the following research questions:

- Do managers' traits matter for a firm's R&D policy?
- Which traits and incentives are associated with a firm's R&D expenditure?

Based on the empirical evidence in the literature, we hypothesize that firms with more risk-taking managers and with more risk-rewarding compensation structures are likely to invest more in R&D. We use executives' age, tenure length, dual role status as a chairman, gender, and cash compensation amount to measure the risk-taking traits. We use Vega as a proxy for the risk-rewarding compensation structure.

To answer the above questions, we test our model using data of 4,463 executive-year observations and their corresponding firms' R&D expenditures. Statistical analyses including ordinary least square, weighted least square, best subset selection, random prediction, and significance tests cutoff points are adopted to ensure the robustness of our empirical model.

Our results suggest that younger, newer, and non-chairman executives whose compensation has a higher sensitivity to stock volatility are associated with higher R&D expenditures. Gender does not appear to influence R&D investments significantly. Our study contributes to the existing literature by uncovering evidence of the relationship between manager traits and R&D investments.

The remainder of the paper is as follows: Section 2 describes data we use in our study. Section 3 presents the results of our empirical analysis. Section 4 concludes the paper.

METHODS

Data

The data includes 4,463 executive observations from Execucomp for public companies with fiscal year ending in 2004. For each firm, the data includes names, titles, tenure, age, gender, and compensation of all executive officers who have control and influence on the capital structure, investment decision, policy, and performance evaluation of a firm. We collect 743 associated firms' accounting data from COMPUSTAT and pair executives with their corresponding firms to create a matched panel data. We name the analysis based on the full sample of 4,463 observations the All-Executives model. Additionally, we select the longest-serving executive of each firm and match the executives with their corresponding firms. We call the empirical model based on the second dataset the Longest-Serving-Executive model. The second data set contains 743 executive-firm observations.

Measurement of Firm and Executive Attributes

The dependent variable is R&D expenditure of each firm. The independent variables include several executive attributes: tenure, age, gender, chairman dummy, cash compensation, Vega, delta and CEO dummy. Control variables also include four firm-level attributes: book leverage, market to book, total assets, and CAPEX. Definitions of these variables are described in Table 1. R&D, delta, Vega, tenure, age, total assets, CAPEX and cash compensation are in natural log. Table 2 presents the summary statistics of the continous variables. As shown in Table 2, our sample firms have an average R&D of 232.45, ranging from 0.33 to 8755.00. Longest-serving executives have higher average delta and alpha than overall executives. On average, the tenure and age of all executives are 7 years and 52. CEOs' compensation has an average of 758.50.

TABLE 1
VARIABLE DEFINITION

Variable	Definition
Managerial Attributes	
Age	Manager's age
Tenure	Number of years of continuous employment with a firm
Female	A dummy variable with 1 for female and 0 for male
CEO	A dummy variable with 1 if the executive served as the CEO of the company and 0 otherwise
Chairman	A dummy variable with 1 if the executive served as a chairman of the company and 0 otherwise
Vega	Dollar change in the executive's wealth for a 1% change in standard deviation of returns
Delta	Dollar change in the executive's wealth for a 1% change in stock price
Cash Compensation	The sum of manager's salary and bonus
CEOchair	A dummy variable with 1 if the executive served as CEO and chairman of the company and 0 otherwise

Variable	Definition
Firm Attributes	
Market to book	Market value of equity to book value of equity
CAPEX	Net capital expenditure
AT	Total assets
Book leverage	The ratio of total debt to total assets
R&D	Research and development expenditure to total assets

TABLE 2
SUMMARY STATISTICS

Variable	Mean	Std Dev	Minimum	Maximum	Median
LogR&D	232.45	752.04	0.33	8755.00	39.92
LogDelta (All-Executives)	0.46	6.47	0.00	313.45	0.07
LogDelta (Longest-Serving-Executive)	1.63	14.25	0.00	313.45	0.23
LogVega (All-Executives)	0.08	0.19	0.00	4.19	0.03
LogVega (Longest-Serving-Executive)	0.18	0.35	0.00	4.19	0.06
LogTenure (All-Executives)	7.00	2.06	1.00	40.00	7.00
LogTenure (Longest-Serving-Executive)	10.00	1.70	3.00	40.00	9.00
LogAge (All-Executives)	52.00	8.00	36.00	73.00	52.00
LogAge (Longest-Serving-Executive)	58.00	5.00	40.00	65.00	55.00
Bookleverage	0.39	0.24	0.02	4.28	0.38
Markettobook	2.32	1.85	0.68	39.53	1.85
LogAT	7009.14	34792.24	5.05	750507.00	1082.81
LogCAPEX	242.71	1149.93	0.12	22077.00	32.46
LogCashcompensation(All-Executives)	758.50	791.72	0.00	9500.00	514.06
LogCashcompensation (L.S.E)	1250.97	1178.43	0.00	9500.00	860.02

STATISTICAL ANALYSIS AND RESULTS

OLS Regression Results

To start with, we test our empirical model using ordinary least squares (OLS) regressions. To answer our research questions, we estimate the following regression model.

$$R\&D_{i,t} = \alpha_i + \gamma_{IO} * \sum_i^n controls_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

where R&D is a firm's research and development expenditure. Controls include manager-level and firm-level attributes: Age, Tenure, Female, CEO, Chairman, Vega, Delta, Cash compensation, CEOchair, Market to book, CAPEX, AT, and Book leverage.

The results for both All-Executives and Longest-Serving-Executive models are presented in Table 3. The coefficient of Vega is 0.221 and significant at the 1% level, indicating that as the Vega of managers increases, they are more likely to undertake R&D investment. R&D increases as a CEO's compensation sensitivity to standard deviation of returns. In addition, the coefficients of age and cash compensation are significantly negative with values of -0.080 and -0.123, respectively. The evidence together suggests that firms with more younger, newer, non-chairman managers with higher Vega tend to invest more in R&D. The gender, CEO dummy, and delta of firms do not show significant influence on R&D expenditures.

The negative coefficients of tenure, age, and chairman are statistically significant, which implies that newer, younger, and non-chairman executives are associated with higher R&D investments. The result for the Longest-Serving-Executive model is similar to that of the All-Executives model. We further find that the influence of the traits associated with the longest serving executives on firm R&D is more profound than the All-Executives model.

TABLE 3
OLS FULL MODEL REGRESSION

	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.137	-1.08	-0.312	-1.11
LogVega	0.221	8.99	0.200	4.15
LogTenure	-0.023	-1.62	0.036	1.02
LogAge	-0.080	-6.74	-0.087	-3.02
GenDum	0.027	0.74	0.000	0.00
ChmnDum	-0.072	-1.90		
LogCashcompensation	-0.123	-3.69	-0.216	-3.65
CeoDum	-0.003	-0.08	-0.032	-0.75
LogDelta	-0.024	-0.92	-0.067	-1.45
Bookleverage	-0.290	-7.44	-0.089	-0.79
Markettobook	0.075	14.11	0.101	6.09
LogAT	0.962	29.51	0.993	13.00
LogCAPEX	-0.200	-7.99	-0.187	-3.20
Adj-Rsq	0.58		0.57	
Observation	4463		743	

Additional Analyses

Best Subset Selection

As an explanatory tool, we apply the best subset selection regression method and select the best model with the highest adjusted R^2 and Cp less than p-value. The best subset model OLS regression results for the All-Executives model and the Longest-Serving-Executive model are shown in Table 4. Based on the results presented by the best subset selection model, we exclude gender dummy and delta from our analysis, as they are less associated with a firm's R&D. In the unreported results, 21 models with different combinations of the independent variables are considered. The model in Table 4 has the highest explanatory power of a firm's R&D investments. The results in Table 4, the best subset model, are consistent with our baseline results in Table 3 that newer, younger, and non-chairman executives are associated with higher R&D investments. The evidence implies that our results are robust to different model specifications.

TABLE 4
OLS BEST MODEL REGRESSION

	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.168	-1.40	-0.196	-0.79
LogVega	0.198	10.83	0.178	4.28
LogTenure	-0.022	-1.69		
LogAge	-0.081	-7.12	-0.078	-2.87
Chmndum	-0.081	-2.78		
Bookleverage	-0.290	-7.86		
Markettobook	0.075	15.03	0.094	6.19
LogAT	0.976	31.35	0.983	13.68
LogCAPEX	-0.207	-8.42	-0.184	-3.26
LogCashcompensation	-0.125	-3.97	-0.221	-3.87
Ceochmn			-0.061	-1.48
Adj-Rsq	0.59		0.60	
Observation	4463		743	

Random Models Prediction

To test the robustness of our model, we employ several additional tests. One important aspect of a good model is to exhibit a prediction power. If the model has significant regression results but fails to predict, the model may not be meaningful to apply to a new problem. To test for the prediction power of our model , we randomly divide the full sample into two halves (subsample 1 and 2) and use subsample 1 to predict the other half, subsample 2. The estimated coefficients are regressed based on subsample 1 and predict the fit intervals for subsample 2 and the probability that the true value of dependent variable in subsample 2 falls into the predicted intervals is examined. Panel A of Table 5 reports the OLS full model prediction results and Panel B of Table 5 reports the best model prediction results. For both All-Executives model and Longest-Serving-Executive model, the best subset models provide better prediction power as reflected in the slightly higher adjusted R-square shown in Panel B. The R-square of the best subset model prediction ranges from 0.60 to 0.62. In comparison, the R-square of the OLS full model prediction is only 0.57.

TABLE 5
MODEL PREDICTION

Panel A: OLS Full Model Prediction

	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.142	-0.85	-0.257	-0.68
LogDelta	-0.031	-0.89	-0.066	-0.90
LogVega	0.219	6.92	0.234	3.11
LogTenure	-0.009	-0.47	0.007	0.14
LogAge	-0.081	-4.87	-0.113	-2.76
Ceodum	0.039	0.9	-0.055	-0.90
Gendum	0.045	0.95	0.239	1.25
Chmndum	-0.060	-1.17		
Bookleverage	-0.286	-5.39	-0.204	-1.24
Markettobook	0.075	10.16	0.118	4.77
LogAT	1.003	22.73	0.967	9.12
LogCAPEX	-0.245	-7.03	-0.139	-1.59
LogCashcompensation	-0.154	-3.92	-0.169	-2.40
Adj-Rsq	0.59		0.57	
Observation	2274 (out of 4463)		393 (out of 743)	

Panel B: Best Subset Model Prediction

	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.060	-0.33	-0.05	-0.170
LogVega	0.240	8.57	0.19	3.570
LogTenure	-0.039	-2.03		
LogAge	-0.104	-6.39	-0.05	-1.490
Chmndum	-0.082	-1.97		
Bookleverage	-0.260	-4.88		
Markettobook	0.072	10.01	0.11	5.160
LogAT	0.976	21.2	0.79	8.020
LogCAPEX	-0.212	-5.84	-0.03	-0.340
LogCashcompensation	-0.109	-2.43	-0.17	-2.640
Ceochmn			-0.10	-1.830
Adj-Rsq	0.60		0.62	
Observation	2208 (out of 4463)		381 (out of 743)	

Weighted Least Square Regressions

Since the data does not meet the constancy of variance assumption, we apply the weighted least square regression method. Firstly, we run the original regression to get the residuals. Then, we compute the absolute value of residuals and run a regression with them on the independent variables to obtain the estimated standard deviations. Finally, we use $1/\boldsymbol{\sigma}^2$ as weights and run regression with these weights. By applying the weighted least square regression, heteroscedasticity problem can be resolved. Results for the full model and best model are shown in Table 6. The results of the weighted least square regressions are consistent with the results of the OLS analysis, suggesting that our baseline findings are consistent across different model specifications and methods.

TABLE 6
WLS MODEL REGRESSION

Panel A: WLS Full Model				
	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.162	-1.64	-0.188	-0.69
LogDelta	-0.098	-4.02	-0.104	-2.30
LogVega	0.277	10.92	0.262	5.31
LogTenure	-0.012	-0.98	0.045	1.33
LogAge	-0.084	-7.37	-0.090	-3.22
Ceodum	0.015	0.52	-0.062	-1.59
Gendum	0.012	0.40	-0.110	-1.02
Chmndum	-0.100	-2.96		
Bookleverage	-0.233	-6.09	-0.102	-0.98
Markettobook	0.070	15.34	0.084	6.82
LogAT	0.929	31.99	0.962	13.75
LogCAPEX	-0.182	-8.37	-0.191	-3.77
LogCashcompensation	-0.091	-9.90	-0.190	-3.10
Adj-Rsq	0.63		0.60	
Observation	4463		743	

Panel B: WLS Best Subset Model				
	All-Executives		Longest-Serving-Executive	
Variable	Coefficient	t-Value	Coefficient	t-Value
Intercept	-0.154	-1.66	-0.096	-0.38
LogVega	0.200	11.39	0.185	4.33
LogTenure	-0.023	-1.94	-0.074	-2.78
LogAge	-0.080	-7.22	0.083	7.78
Chmndum	-0.108	-4.12	0.921	13.60
Bookleverage	-0.223	-6.18	-0.168	-3.32
Markettobook	0.067	15.92	-0.189	-3.17
LogAT	0.932	33.26		
LogCAPEX	-0.191	-8.91		
LogCashcompensation	-0.090	-13.98		
Ceochmn			-0.070	-1.81
Adj-Rsq	0.66		0.60	
Observation	4463		743	

T-cutoff Points

In Table 7, we present three t-cutoff points obtained based on Raftery, Kass, and Adrian (1995) so that t-values are comparable across the two different sample sizes of models. For cutoff point 1 (positive evidence), t-value equals the square root of log (n) (n is the sample size). For cutoff point 2 (strong evidence), t-value equals the square root of log (n) +6. For cutoff point 3 (decisive evidence), t-value equals the square root of log (n) +10. By transforming the t-values based on sample size, one can compare coefficient significance of the All-Executives model and the Longest-Serving-Executive model. Based on t cutoff point 1, for the OLS full model, 7 out of 12 variables are statistically significant in the full model compared with 6 out of 11 being statistically significant for Longest-Serving-Executive model. For both models, adjusted R-squares are similar, which implies that both managerial and firm attributes contribute to explaining R&D.

TABLE 7
T-CUTOFF POINTS

Models	n	T-cutoff 1	T-cutoff2	T-cutoff3
All-Executives	4463	1.91	3.11	3.21
Longest-Serving-Executive	743	1.69	2.98	3.20

CONCLUSION

This study contributes to the literature by providing evidence that executive compensation structures and managers' individual traits influence corporate R&D investment. The All-Executives model tests how the combination of managerial factors of all top named executives influence R&D. The Longest-Serving-Executive model is designed to test how the person who stays the longest and probably the most influential in the firm would impact R&D. Similar results are observed for both models.

We use Vega (the sensitivity of CEO's stock option portfolio to stock return volatility) to measure managers' incentives to take risk due to an anticipated gain or loss in personal wealth. Our result shows that as Vega increases, firms invest more in R&D. We measure management entrenchment using the lengths of executive tenures, ages, the amount of cash compensation, and whether a CEO serves as a chairman. The result suggests that firms with less entrenched management (i.e., shorter tenure, younger age, less cash compensation, and no duality) invest more in R&D. On the other hand, we do not find any significant evidence that the executive gender influences R&D intensity.

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