7-16-2021

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Recommended Citation

Naaman, C., & Sun, L. (2021). CEO power and R&D investment. Accounting Research Journal.

CEO Power and R&D Investment

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Abstract

- **Purpose**: This study examines whether and how the power of a chief executive officer (CEO) relates to firm-level research and development (R&D) investment.
- **Design/methodology/approach**: The authors employ clustered standard errors OLS regression using a large sample of U.S. firms from 1994 to 2017.
- **Findings**: The authors find a significant negative relation between CEO power and R&D investment, suggesting that firms with more powerful CEOs are less likely to invest in R&D activities. Besides, we find that this significant negative relation is largely driven by firms with weaker corporate governance.
- **Originality**: This study contributes to the finance literature on the impact and consequences of having powerful CEOs and the financial accounting literature on the determinants of R&D expenditures.

CEO Power and R&D Investment

1. Introduction

In today's competitive and dynamic business environment, it is critical for firms to produce a steady stream of innovations (Hamel and Prahalad, 1994). Many prior studies including Balkin *et al*. (2000) point out that the primary source of innovation is research and development investment (R&D investment). R&D investment includes all tangible and intangible resources (e.g., financial resources, technological resources, and necessary personnel) devoted to a firm's innovation activities. R&D investment is critical because it is a key driver for a firm to maintain its competitive advantage (O'Brien, 2003). According to a study conducted by PricewaterhouseCoopers (PWC), "*R&D spending among the Global Innovation 1000 overall increased 11.4 percent in 2018, to a record high of $782 billion, reflecting R&D spending increases in all regions and nearly all industries*".[1] However, such investment is also very risky because R&D projects place substantial demand for firm resources, resulting in an adverse impact on current performance.[2] More importantly, the payoffs of R&D projects are uncertain and unpredictable with a likelihood of failure.

The CEO is the central decision-maker and has the greatest power to make critical investment and resource allocation decisions (Barker and Mueller, 2002) such as investment in R&D activities. Prior literature unveils the incentives of CEOs on R&D spending (e.g., Balkin *et al*., 2000; Cheng, 2004; Cheng *et al.*, 2016); however, the effect of powerful CEOs on R&D investment is still unexplored. The consequences of CEO power are extensively examined in the literature, but the results are inconclusive. Adams *et al*. (2005) argue that the powerful CEO's decision-making ability leads to either good or bad consequences. While some research suggests that CEO power increases firm performance and outcomes (e.g., Daily and Johnson, 1997; Keltner *et al*., 2003), others argue that powerful CEOs lead to negative outcomes such as poor firm performance and value (e.g., Bebchuk *et al*., 2011), low bond ratings (e.g., Liu and Jiraporn, 2010), and an increase in agency conflicts (e.g., Dunn, 2004). Despite the increased attention on the consequences of having powerful CEOs, there is limited empirical evidence on whether and how powerful CEOs influence a firm's innovation activities.

The purpose of our study is to examine the impact of CEO power on R&D investment. On one hand, we posit a positive relation between CEO power and R&D investment because powerful CEOs are high ability CEOs (Daily and Johnson, 1997; Keltner *et al.*, 2003) and such managers are more likely to invest in R&D activities (Kor 2006; Kroll *et al*., 2008). On the other hand, based on the agency theory, we predict a negative relation between CEO power and R&D investment. Prior research suggests that more powerful CEOs reflect a higher level of agency conflicts, which causes such CEOs to invest less in R&D activities. Using a large panel sample with more than 28, 000 firm-year observations from 1994 to 2017, we document a significant negative relation between CEO power and R&D investment. This evidence suggests that firms with more powerful CEOs are less likely to devote resources to R&D activities, consistent with the agency theory. We perform a battery of additional tests and still obtain consistent results, suggesting that our primary results are robust. In addition, we find that this relation is mainly driven by firms with weaker corporate governance.

This study makes several noticeable academic and practical contributions. First, the study contributes to the stream of accounting literature that examines the determinants of R&D investments. For example, Fedyk and Khimich (2018) show that firms overinvest in R&D if they are at the growth stage, unprofitable, or belong to science-driven industries, while firms underinvest in R&D to avoid losses. Our findings add to this literature by investigating a different reason for underinvestment in R&D activities, which is determined by CEO power.

Moreover, this study extends the literature on characteristics and incentives of CEOs to over/under-invest in R&D. For example, prior literature shows that R&D investment is determined by CEO tenure (Chen, 2013; Dechow and Sloan, 1991), short-term compensation (Balkin *et al*., 2000; Cheng, 2004), stock option (Wu and Tu, 2007), and real earnings management (Cheng *et al.*, 2016). Our results also extend the findings of Barker and Mueller (2002) that R&D investment can be largely explained by CEO personal characteristics. We show a new characteristic of CEOs, CEO power, which may affect R&D investment. Third, the study contributes to the corporate governance literature; in particular, to the agency problem in the presence of weak governance. We further support the findings of Cheng (2008) by using different proxies for governance and CEO power; we use a more comprehensive measure of corporate governance effectiveness, the entrenchment index developed by Bebchuck *et al.* (2009). Fourth, from the public interests' perspective, our study joins the public debate on whether having powerful CEOs is beneficial to an organization. Prior research suggests that it is rather difficult to predict the consequences of powerful CEOs (Larcker and Tayan, 2012). Hence, our study contributes to a more comprehensive understanding of the consequences of CEO power. Our findings show that powerful CEOs tend to undervalue the long-term benefits of R&D investment. Lastly, this study has practical implications. For example, investors that focus on the long-term success of a firm may invest in firms with less powerful CEOs because such firms are less likely to invest in R&D investment.

The remainder of our study is organized as follows. Section 2 presents the literature review and develops the hypotheses. Section 3 presents the research design and Section 4 reports the primary results. Section 5 presents the results of additional tests. Section 6 concludes our study.

2. Literature Review and Hypotheses Development

Prior research on R&D activities can be classified into two categories. The first category investigates whether R&D expenditures can bring future benefits. For example, Curtis et al. (2020) find that R&D expenditures are positively related to future firm profitability and this relation becomes weaker over time. The second category examines the factors that may influence a firm's R&D activities. In this category, prior research examines the impact of stock ownership on R&D investment (e.g., Graves, 1988; Baysinge *et al*., 1991; Hansen and Hill, 1991; Chen and Huang, 2006; Deutsch, 2007; Chen and Hsu, 2009). For instance, Chen and Huang (2006) find a significant positive relation between employee stock ownership and R&D expenditures, suggesting that employee stock ownership can help mitigate agency problems. On the contrary, Chen and Hsu (2009) reveal a negative relation between family ownership and R&D investment, suggesting that family-owned companies may undervalue the importance of long-term R&D activities. Kim and Lu (2011) show that CEO ownership can influence R&D spending when external governance is weak. Some studies (e.g., Scherer, 1984) find that R&D investment is industry-specific, showing that some industries such as high-tech industries naturally have high R&D spending. Studies including Hoskisson and Hitt (1988) and Baysingner and Hoskisson (1989) find that the level of R&D activities varies with a firm's business strategies, highlighting the dynamic nature of R&D investment.

Top managers play a crucial role in setting the firm's strategic plan, R&D agenda, and capital investment (Chan *et al.*, 2020). More specifically, the CEO is the central decision-maker and has the greatest power to make critical investment and resource allocation decisions (Barker and Mueller, 2002). Prior research explores the impact of CEO incentives on R&D spending from different theoretical perspectives. According to the Upper-Echelons Theory (Hambrick and Mason, 1984), the actions of CEOs are based on their understanding of the strategic situations they confront. This understanding is significantly shaped by their tenure (Souder *et al.*, 2012), which mirrors their paradigms, skills, knowledge, and cognition orientation (Barker and Mueller, 2002; Richard *et al.*, 2009). Chen (2013) extends this finding by uncovering an inverted-U relation between CEO tenure and R&D spending and documenting the existence of the horizon problem (i.e., earnings-based performance measures provide executives with incentives to focus on short-term performance), consistent with Dechow and Sloan (1991) that find CEOs spend less on R&D during their last years in office. Cheng (2004) also documents that changes in R&D spending are positively related to changes in CEO compensation in the presence of the horizon and myopia problems. Using a small sample of high-tech firms, Balkin *et al*. (2000) find that CEO's short-term compensation (i.e., salary) is positively related to a firm's innovation, which suggests that CEOs with higher short-term compensation tend to invest more in R&D investment. However, the relation between the CEO's long-term compensation and R&D investment is insignificant. Manso (2011) proposes theoretically that incentive contracts should ensure a long-term commitment to motivate managers to explore new ideas, rather than exploit the existing ones. Using only four R&D intensive industries, Wu and Tu (2007) find that CEOs' stock option is more positively related to R&D spending when slack resources or firm performance are high.

In a similar vein, other studies examine the impact of CEO personal characteristics on R&D spending. For example, Barker and Mueller (2002) investigate the impact of several CEO personal characteristics including education, advanced science-related degree, age, and career experience in certain areas on R&D investment. The authors find that advanced science-related degrees, age, and significant experience in marketing or engineering are related to R&D investment, suggesting that a firm's R&D activities can be largely explained by CEO characteristics. Serfling (2014) uncovers a negative relation between CEO age and R&D spending.

Despite the vast body of literature on the link between CEO characteristics and R&D activities, yet little research examines the impact of CEO power (an important CEO characteristic) on R&D investment. Prior research on CEO power has focused on the consequences of powerful CEOs, as the advantages and disadvantages of having powerful CEOs are widely discussed in the literature with inconclusive findings. Adams *et al*. (2005) find that firm performance rises and falls depending on the power of the CEO. A powerful CEO is considered a valuable asset to the firm and its stakeholders if this CEO is able to make correct corporate decisions leading to superior firm performance. On the contrary, the firm might face incredible damages if a powerful CEO makes wrong or bad decisions.

On the one hand, empirical studies suggest a positive relation between CEO power and firm performance and outcomes. Daily and Johnson (1997) find that CEO power and firm performance are highly correlated. Specifically, they suggest that firm operating performance is both an antecedent condition and outcome of CEO power. Moreover, Breit *et al.* (2019) find that CEO power increases employee productivity. This leads to the conclusion that powerful CEOs can implement their decisions more efficiently. As a result, the positive relation between CEO power and firm performance suggests that powerful CEOs are high ability CEOs or more capable CEOs. If this is the case, we expect a positive relation between CEO power and R&D investment because prior research suggests that more capable managers better understand R&D spending and the benefits of such spending (e.g., Kor 2006; Kroll *et al.*, 2008). Specifically, Kroll *et al*. (2008) state that capable managers are better able to understand the short-term and long-term implications of R&D investment, to implement R&D strategies, and to identify projects with positive net present value. If more powerful CEOs lead to stronger firm performance, we intuitively expect that such CEOs are better able to allocate more resources to their R&D activities due to abundant resources (e.g., financial resources) generated by stronger performance. Thus, based on the above arguments, we posit a positive relation between CEO power and R&D spending by proposing the following hypothesis:

H1: CEO power is positively related to R&D investment.

On the other hand, other studies imply that CEO power may lead to several negative outcomes. Dunn (2004) argues that an increased concentration of power increases agency conflicts, motivating CEOs to take self-serving actions and engage in illegal corporate behaviors. Bebchuk *et al*. (2011) document that firms with more powerful CEOs demonstrate inferior operating performance and lower market valuation. Studies also document a significant negative relation between CEO power and capital structure (Jiraporn *et al*., 2012), and bond ratings (Liu and Jiraporn, 2010). In risky or volatile environments, Han *et al.* (2016) find that powerful CEOs perform worse than their counterparts. Moreover, Dikolliet *et al*. (2018) find that powerful CEOs are less likely to use relative performance evaluation, suggesting that powerful CEOs have more incentives to avoid risks and to engage in opportunistic behavior. These studies suggest that powerful CEOs are more likely to engage in opportunistic corporate behavior, inconsistent with the objectives of shareholders. Thus, CEO power is highly correlated with agency conflicts. According to Jensen and Meckling (1976), agency problems arise when agents pursue personal objectives, which can be explained by the difference in risk preferences between principals and agents. Agency theory predicts that principals are often risk-neutral because they can invest in different companies to mitigate risks. Agents are often risk-averse because their compensation and career are solely dependent on their company. Thereby, when agency problems arise, agents are less likely to undertake risky projects such as R&D investment. If the operating performance of firms with more powerful CEOs becomes worse, we predict that such firms may not be able to devote resources to R&D spending due to poor performance. Taken together, we posit that more powerful CEOs are less likely to invest in R&D activities, leading to the following hypothesis:

H2: CEO power is negatively related to R&D investment.

3. Research Design

3.1 Measuring CEO Power

We follow Bebchuk *et al*. (2011) to measure the CEO power in our study. Bebchuk *et al*. (2011) introduce an objective measure of CEO power, known as the CEO Pay Slice (CPS). CPS is the fraction of the CEO's total compensation to the sum of the compensation of the top five executives (including the CEO). Total compensation is obtained from the ExecuComp database, which usually includes salary, bonus, other pay, long-term incentive payouts, restricted stocks, stock option, and other benefits. Bebchuk *et al*. (2011) argue that the CPS is an accurate and objective proxy for CEO power because this ratio captures the relative significance of the CEO in the organizational hierarchy. Particularly, they emphasize (at least) three advantages of using the CPS as a proxy for CEO power: (1) it captures numerous observable and unobservable factors in the dynamics of top executives in an organization, (2) it captures firm-level characteristics well since this measure is based on the ratio of the CEO pay to the other executives in the same firm, and (3) it contains significant information value as CPS is strongly related to important firm performance indicators such as profitability and market value. The higher the CPS, the more powerful the CEO.

3.2 Empirical Specification

To investigate the impact of CEO power on R&D investment, we use the following regression equation:

$$\text{R\&D Investment} = \alpha_0 + \alpha_1\textbf{CEOPOWER} + \alpha_2\text{AGE} + \alpha_3\text{TENURE} + \alpha_4\text{COMP} + \alpha_5\text{Real\_EM} + \alpha_6\text{lnTA} + \alpha_7\text{AD} + \alpha_8\text{LEV} + \alpha_9\text{ROA} + \alpha_{10}\text{SaleGrowth} + \alpha_{11}\text{MTB} + \alpha_{12}\text{OpCash} + \alpha_{13}\text{Loss} + \alpha_{14}\text{BIG4} + \alpha_{15}\text{SGA} + \alpha_{16}\text{Cash} + \alpha_{17}\text{FinCash} + \alpha_{18}\text{CapX} + \alpha_{19}\text{PPE} + \text{Industry Indicators} + \text{Year Indicators} + \varepsilon \qquad \text{[Equation 1]}$$

In Equation 1, we use CEO Pay Slices (CPS) to measure CEOPOWER. The dependent variable, R&D Investment, alternatively represents the following two measures, RD and RDEmpl. RD is the total research and development expenses (XRD) scaled by total firm assets (AT). RdEmpl is the total research and development expenses (XRD) scaled by total employees (EMP). If our first hypothesis (H1) is valid, we expect the coefficient on CEOPOWER (α_1) to be significant and positive. That is, more powerful CEOs tend to invest more in their R&D activities. If our second hypothesis (H2) is valid, we expect the coefficient on CEOPOWER (α_1) to be significant and negative, which implies that firms with more powerful CEOs have lower R&D investment.

Consistent with prior research (e.g., Cheng, 2004; Kim and Lu, 2011; Serfling, 2014), we first control for several CEO characteristics that are closely related to CEO power, namely CEO age (AGE), CEO tenure (TENURE), CEO compensation (COMP). We also include the level of real earnings management (Real_EM) because R&D spending can be manipulated in real earnings management (Cheng, 2004; Cheng *et al*., 2016). Next, we control for factors that may influence R&D activities, which are similar to those used in prior research (e.g., Biddle *et al*., 2009; Canace *et al*., 2018; Darrough and Rangan, 2005; Jia, 2019; Perry and Grinaker, 1994; Ramalingegowda *et al*., 2013). Specifically, we control for firm size (measured by the natural logarithm of total assets), leverage (measured by the total debt to total assets ratio), and profitability (measured by the return-on-assets ratio). For example, larger firms may be more likely to invest in R&D activities and profit from them, more profitable firms may also be increasingly motivated to commercialize from R&D activities. Management's risk tolerance influences the firm's likelihood of investing in innovation, we proxy to risk tolerance by leverage. Sales growth and market to book ratio control for growth because growth opportunities of a firm can affect its level of innovativeness. Moreover, liquidity is an important determinant of R&D investment; we control for cash from operations, cash and short-term investments, and cash from financing activities, and control for additional expenses that might affect the liquidity such as advertising expenses, and selling, general and administrative expenses. We also control for asset tangibility (measured by net property, plants, and equipment) and capital expenditures, because these expenditures represent investment decisions that compete for the same resources as R&D. Finally, we control for whether a firm uses a Big4 auditor and whether a firm reports loss in a given year.

In testing our hypotheses, we use clustered standard errors OLS regression because our sample is a panel sample. All continuous variables in Equation 1 are winsorized at the 1% and 99% percentiles to curtail the influences of any outliers. Industry indicators (based on Fama and French 48 industry classification) and year indicators are also included in the baseline regression model. Please refer to Appendix 1 for detailed variable definitions.

3.3 Sample Distribution and Descriptive statistics

Our sample is an intersection of data from the ExecuComp database for CEO compensation information and the Compustat database for financial statement information. Our final sample consists of 28,825 firm-year observations from 1994 to 2017. Table 1 reports the full sample descriptive statistics. The mean values of RD and RDEmpl are 0.030 and 15.528, respectively. The mean value of CPS is 0.397. The average CEO age is about 56. The mean values of MTB, LEV, and ROA are 3.380, 0.196, and 0.040, respectively, suggesting that our sample firms demonstrate normal operating performance. The mean value of BIG4 is 0.936, showing that the majority of our sample firms use one of the Big 4 accounting firms as their auditor.

[insert Table 1 about here]

The correlation coefficient (untabulated) between CPS and RD is -0.044 with a p-value of less than 0.0001, suggesting a significant negative correlation between CEO power and R&D investment. This evidence indicates that firms with more powerful CEOs are less likely to invest in their R&D activities, lending initial support to our second hypothesis (H2). However, the correlation between CPS and RDEmpl is insignificant. Most correlation coefficients are fairly small, which may suggest that multicollinearity should not be a major concern in our study.

4. Primary Findings

To test our hypotheses, we estimate our baseline regression model and report results in Table 2. Column 1 (Column 2) shows that the coefficient on CPS is -0.023 (-16.949) with a t-value of -12.06 (-9.43) where the dependent variable is RD (RDEmpl). The findings indicate a significant negative relation between CPS and R&D investment, suggesting that firms with powerful CEOs are less likely to invest in R&D activities. Hence, H2 is strongly supported.

Both columns present that R&D investment is positively related to MTB, Cash, CapX, and Big4, and negatively related to Ad, LEV, ROA, SGA, FinCash, OpCash, and PPE. For the most part, the above relations are in line with general expectations. For example, the significant positive relation between R&D investment and Cash suggests that firms with more cash tend to invest more in their R&D activities.

Our primary findings are economically meaningful. Column 1 reports an adjusted R^2 of 0.6307, which suggests that the model (where the dependent variable is RD) explains approximately 63 percent of the variation. As shown in Column 2, the specification (where

RDEmpl is the dependent variable) explains approximately 48 percent of the variation. Based on Column 1, a standard deviation increase in CPS is associated with an approximately 9 % decrease in RD. Based on Column 2, a standard deviation increase in CPS is associated with an approximately 13 % decrease in RDEmpl.

[insert Table 2 about here]

5. Additional Tests

5.1 Alternative Innovation Measures

Prior research (e.g., Gao *et al*., 2016) uses the number of patents as a measure of innovation, by arguing that patents reflect the outcomes and the success rates of innovation activities. In other words, the measure of patents complements the measure of R&D investment in the context of innovation activities. Hence, using patents (PAT) as the dependent variable, we re-estimate Equation 1 and report results in Table 3. PAT is the natural logarithm of the total number of patents + 1. Table 3 shows that the coefficient on CPS is -0.151 with a t-value of -1.88, suggesting a significant negative relation between CEO power and patenting activities. Hence, our primary findings are robust to this alternative innovation measure.

[insert Table 3 about here]

In a similar vein, we use another measure, namely innovation efficiency, which is calculated as the ratio of total patents to total R&D investment (e.g., Gao *et al*., 2016). We re-estimate our baseline model using innovation efficiency as the dependent variable and report results in Table 4. The coefficient on CPS is -0.001 with a t-value of -1.89, still supporting our primary findings.

[insert Table 4 about here]

5.2 Alternative CEO Power Measures

Prior studies (e.g., Adams *et al*., 2005; Combs *et al*., 2007) use CEO duality to proxy for CEO power. CEO duality means that the CEO is also the chairperson of the board. When a CEO chairs the board, the CEO is considered more powerful. Therefore, we use CEO duality (CEO_DUALITY) as an alternative measure of CEO power in our study. Additionally, we use an indicator variable (H_CPS) as another alternative measure. H_CPS takes a value of one if an observation's CPS is greater than the median and zero otherwise. Using CEODULITY and H_CPS, we re-estimate Equation 1 and report results in Table 5.

As shown in Table 5, the coefficient on CEO_DUALITY is -0.004 with a t-value of -7.42 and -4.816 with a t-value of -9.62 where the dependent variables are RD and RDEmpl, respectively. Column 3 (Column 4) reports that the coefficient on H_CPS is -0.004 (-3.714) with a t-value of -7.47 (-6.39), where the dependent variable is RD (EDEmpl). The findings imply that the significant negative relation between CEO power and R&D investment is robust to alternative CEO power measures.

[insert Table 5 about here]

5.3 Changes analysis

To curtail concerns about omitted correlated variables (e.g., Glaeser and Guay, 2017; Armstrong and Kepler, 2018), we perform a change analysis. Specifically, we conduct a regression analysis of regressing the changes in R&D (ΔRD and ΔRDEmpl) investment on the changes on CPS (ΔCPS) and other control variables. As shown in Table 6, the coefficient on ΔCPS is -0.008 with a t-value of -5.24 where the dependent variable is ΔRD in Column 1. However, the coefficient on CPS is insignificant using ΔRDEmpl as the dependent variable. Overall, the results of the change analysis provide some evidence to suggest that an increase (a decrease) in CEO power can lead to a decrease (an increase) in R&D investment, lending additional support to our primary findings.

[insert Table 6 about here]

5.4 Two-stage OLS regression

To mitigate concerns about endogeneity such as reverse causality (e.g., Glaeser and Guay, 2017; Armstrong and Kepler, 2018), we perform a two-stage OLS regression analysis (2SLS). Specifically, we use the industry-year median of CEO power (Ind_Year_Median_CPS) and the lag of CEO power (lagCPS) to predict an instrumental variable (Predicted _CPS) in the first stage. We next re-estimate our baseline model using the instrumental variable from the first stage of 2SLS. Column 1 of Table 7 shows the results of the first stage. The coefficients on Ind_Year_Median_CPS is 0.564 with a t-value of 9.25, and lagCPS is 0.353 with a t-value of 73.28 suggest that our selection of IVs is appropriate. Columns 2 and 3 report the results of the second stage where the dependent variable is RD and RDEmpl, respectively. The coefficient on Predicted_CPS is -0.021 with a t-value of -4.31 in Column 2 and -16.861 with a t-value of -3.75 in Column 3. Taken together, results of 2SLS support a significant negative relation between CEO power and R&D investment, consistent with our primary findings. We believe that such results may greatly curtail concerns about reverse causality in our study.

[insert Table 7 about here]

5.5. The Role of Corporate Governance

Prior literature has shown that effective corporate governance reduces opportunistic behavior of managers and limit CEOs' power. For example, Cheng (2008) suggests that firms with larger boards have lower R&D spending. Accordingly, we anticipate that our primary findings are further confirmed for firms with weaker governance because firms with stronger governance may have already restricted their CEO power. For this analysis, we use the entrenchment index (E-index) to proxy for corporate governance effectiveness (Bebchuk *et al.*, 2009). A low E-index suggests stronger corporate governance and vice versa. It is documented in prior research (e.g., Bebchuk *et al*.,2009) that this index is significantly related to lower firm valuation and negative abnormal returns.

In this test, we insert a governance variable (EI) and an interaction term of CPS×EI into Equation 1 and report the results of estimating this modified model in Table 8. EI is an indicator variable that takes a value of 1 if the value is less than the median E-index value and otherwise 0. Column 1 of Table 8 presents that the coefficient on CPS is -0.019 with a t-value of -6.18 where the dependent variable is RD. More importantly, the coefficient on the interaction term is -0.033 with a t-value of -2.11. Similarly, Column 2 shows that the coefficient on CPS is -19.753 with a t-value of -5.52, and on CPS×EI is -31.216 with a t-value of -1.76. The significant negative coefficients on CPS×EI suggest that the impact of CEO power on R&D investment is stronger when the governance is weaker. In other words, our primary findings are more pronounced for firms with relatively weaker governance. Collectively, the results of Table 8 suggest that our primary evidence (a significant negative relation between CEO power and R&D investment) is largely driven by firms with weaker governance mechanisms, consistent with our prediction.

[insert Table 8 about here]

7**. Conclusion**

In this study, we examine the impact of having more powerful CEOs on R&D spending. We find that firms with more powerful CEOs are less likely to invest in R&D activities. In addition, our primary findings are mainly driven by firms with weaker governance. Overall, our results suggest that having powerful CEOs may have a negative impact on corporate innovation activities, which is consistent with agency theory and prior research documenting the negative consequences of having powerful CEOs.

There exists a public ongoing debate on whether using powerful CEOs results in positive or negative outcomes. By using a negative link between CEO power and R&D investment, our study joins this public debate and contributes to a more comprehensive understanding of CEO power. Our results may interest investors that focus on the long-term success of a firm and different stakeholders that may have concerns about excessive CEO power.

Like many other research studies, our study has several limitations. For example, our sample firms are large public firms in the United States because firms reporting the compensation data of their executives including the CEO to the ExecuComp database are large firms. Thereby, whether our primary findings hold for smaller, private, or international firms is still unknown. Next, although prior research has extensively used the CPS measure to proxy for CEO power, it is still an approximate measure. Additionally, other innovation measures may also exist because a firm’s innovation activities are broad in nature. Thereby, we believe that more precise measures of CEO power and other innovation measures may even lead to stronger results. Collectively, researchers can explore the above issues in future studies.

Appendix 1
Variable Definitions

Variable		Definition
RD	=	Research and development expenditures (XRD), scaled by total assets (AT);
RDEmpl	=	Research and development expenditures (XRD), scaled by total number of employees (EMP);
CPS	=	CEO pay slice (CPS), measured as the ratio of the CEO's total compensation to the total compensation of the top-five executives including the CEO;
AGE	=	The age of the CEO;
TENURE	=	The tenure of the CEO;
COMP	=	Total compensation of the CEO (COMP) scaled by total assets (AT).
Real_EM	=	Real earnings management, we follow Roychowdhury (2006) and estimate abnormal levels of discretionary expenses (advertising, R&D, and SG&A).
lnTA	=	Firm size, as the natural log of total assets (AT);
Ad	=	Advertising intensity, as advertising expenses (XAD) scaled by total assets (AT);
LEV	=	Leverage ratio, measure as the ratio of long-term liabilities (DLTT) to total assets (AT,);
ROA	=	Return on assets, as income before extraordinary items (IB) scaled by total assets (AT);
SaleGrowth	=	Change in Sale (SALE) divided by prior year's ending sale;
MTB	=	Market-to-book ratio, as market value of common shares (CSHO) × (PRCC_F) divided by total book value of common shares (CEQ);
OpCash	=	Cash flows from operating activities (OANCF) scaled by total assets (AT);
Loss	=	An indicator variable that equals one if a firm reports a loss otherwise zero;
Big4	=	An indicator variable that equals one if a firm uses a BIG 4 auditor and zero otherwise;
SGA	=	Selling, general and administrative expense (XSGA) scaled by total assets (AT);
Cash	=	Cash and short -term investments (CHE) scaled by total assets (AT);
FinCash	=	Cash from Financing activities (FINCF) scaled by total assets (AT);
CapX	=	Capital expenditures (CAPX) scaled by total assets (AT);
PPE	=	Property, Plant & Equipment (net) (PPENT) scaled by total assets (AT);

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Table 1
CEO Power and R&D Investment
Sample Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	P25	Median	P75
RD	28,825	0.030	0.056	0.000	0.000	0.036
RDEmpl	28,825	15.528	43.249	0.000	0.000	10.748
CPS	28,825	0.397	0.116	0.328	0.397	0.463
AGE	28,825	55.779	6.977	51.000	56.000	60.000
TENURE	28,825	7.233	7.086	2.000	5.000	10.000
CEOGENDER	28,825	0.975	0.156	1.000	1.000	1.000
COMP	28,825	3.313	4.721	0.777	1.824	3.876
Real_EM	28,825	-0.035	0.227	-0.146	-0.003	0.085
lnTA	28,825	14.396	1.593	13.242	14.298	15.463
Ad	28,825	0.012	0.030	0.000	0.000	0.007
LEV	28,825	0.196	0.160	0.039	0.187	0.305
ROA	28,825	0.040	0.097	0.018	0.048	0.085
SaleGrowth	28,825	0.102	0.245	-0.008	0.071	0.172
MTB	28,825	3.380	3.895	1.517	2.301	3.729
OpCash	28,825	0.099	0.083	0.059	0.096	0.142
Loss	28,825	0.173	0.379	0.000	0.000	0.000
Big4	28,825	0.936	0.244	1.000	1.000	1.000
SGA	28,825	0.223	0.205	0.068	0.175	0.322
Cash	28,825	0.143	0.165	0.023	0.078	0.206
FinCash	28,825	-0.011	0.105	-0.061	-.0175	0.022
CapX	28,825	0.055	0.052	0.021	0.039	0.070
PPE	28,825	0.295	0.236	0.105	0.222	0.438

Table 2
CEO Power and R&D Investment
Primary Results

	Column 1	Column 2
	Dep. Var. = RD	Dep. Var. = RDEmpl
CPS	**-0.023***** **(-12.06)**	**-16.949***** **(-9.43)**
AGE	-0.000*** (-5.91)	-0.140*** (-4.96)
TENURE	0.002*** (4.27)	1.358*** (3.37)
COMP	0.002*** (25.81)	1.087*** (19.12)
Real_EM	-0.108*** (-74.37)	-67.076*** (-49.90)
lnTA	-0.001*** (-4.97)	0.397** (2.30)
Ad	-0.287*** (-34.12)	-142.647*** (-18.30)
LEV	-0.034*** (-20.17)	-13.238*** (-8.55)
ROA	-0.112*** (-32.90)	-63.145*** (-20.00)
SaleGrowth	-0.005*** (-5.29)	2.458*** (2.79)
MTB	0.001*** (20.25)	0.796*** (14.42)
OpCash	-0.068*** (-18.52)	-41.072*** (-12.14)
Loss	-0.001 (-1.56)	0.911 (1.35)
Big4	0.007*** (7.48)	5.766*** (7.12)
SGA	-0.037*** (-19.10)	-64.648*** (-36.23)
Cash	0.083*** (48.92)	81.179*** (51.53)
FinCash	-0.035*** (-14.79)	-12.198*** (-5.55)
CapX	0.072*** (11.74)	32.009*** (5.61)
PPE	-0.010*** (-5.41)	-23.123*** (-14.13)
Constant	0.026*** (5.87)	4.659 (1.14)
Industry Indicators	Yes	Yes
Year Indicators	Yes	Yes
Observations	28,825	28,825
Adjusted R^2	0.6307	0.4773

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 3
CEO Power and R&D Investment
Alternative R&D Measure, Number of Patents

	Dep. Var. = PAT
CPS	**-0.151***
	(-1.88)
AGE	-0.004***
	(-3.15)
TENURE	-0.043**
	(-2.39)
COMP	0.002
	(0.74)
Real_EM	-1.239***
	(-21.82)
lnTA	0.434***
	(58.47)
Ad	-3.549***
	(-10.81)
LEV	-1.102***
	(-16.15)
ROA	-0.878***
	(-6.46)
SaleGrowth	-0.302***
	(-8.17)
MTB	0.027***
	(10.30)
OpCash	-0.035
	(-0.24)
Loss	0.012
	(0.40)
Big4	0.218***
	(5.15)
SGA	-0.453***
	(-5.99)
Cash	0.927***
	(13.56)
FinCash	-0.679***
	(-6.88)
CapX	3.013***
	(12.52)
PPE	-0.440***
	(-7.24)
Constant	-5.677***
	(-40.52)
Industry Indicators	Yes
Year Indicators	No
Observations	19,584
Adjusted R^2	0.4262

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 4
CEO Power and R&D Investment
Alternative R&D Measure, Innovation Efficiency

	Dep. Var. = PAT/R&D
CPS	**-0.001***
	(-1.89)
AGE	0.000**
	(2.49)
TENURE	0.000
	(0.10)
COMP	0.000**
	(2.42)
Real_EM	-0.000
	(-0.38)
RD	-0.002**
	(-2.04)
lnTA	-0.000***
	(-3.74)
Ad	-0.001
	(-0.56)
LEV	0.001**
	(2.47)
ROA	0.001
	(1.39)
SaleGrowth	0.000
	(0.57)
MTB	0.000
	(0.04)
OpCash	-0.001
	(-1.10)
Loss	0.000
	(0.74)
Big4	0.000
	(0.55)
SGA	-0.000
	(-0.76)
Cash	-0.000
	(-1.09)
FinCash	-0.001***
	(-3.79)
CapX	0.000
	(0.37)
PPE	-0.000
	(-0.55)
Constant	0.001
	(0.40)
Industry Indicators	Yes
Year Indicators	No
Observations	6,534
Adjusted R^2	0.0157

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 5
CEO Power and R&D Investment
Alternative CEO Power Measures

	Column 1	Column 2	Column 3	Column 4
	Dep. Var. = RD	Dep. Var. = RDEmpl	Dep. Var. = RD	Dep. Var. = RDEmpl
CEO_DUALITY	**-0.004***** **(-7.42)**	**-4.816***** **(-9.62)**		
H_CPS			**-0.004***** **(-7.47)**	**-3.714***** **(-6.39)**
AGE	-0.000*** (-3.59)	-0.064 (-1.53)	-0.000*** (-4.09)	-0.137*** (-3.57)
TENURE	0.002*** (4.31)	1.980*** (4.74)	0.002*** (3.92)	1.391*** (3.61)
COMP	0.001*** (7.63)	0.937*** (5.37)	0.001*** (7.60)	1.000*** (5.41)
Real_EM	-0.116*** (-26.57)	-73.899*** (-14.58)	-0.108*** (-22.61)	-66.937*** (-13.17)
lnTA	-0.001*** (-4.19)	0.510** (2.37)	-0.001*** (-4.55)	0.356* (1.74)
Ad	-0.374*** (-23.66)	-184.052*** (-14.15)	-0.288*** (-17.90)	-143.033*** (-10.88)
LEV	-0.040*** (-15.68)	-15.054*** (-8.22)	-0.034*** (-13.37)	-13.623*** (-6.99)
ROA	-0.121*** (-14.09)	-66.485*** (-8.79)	-0.113*** (-12.77)	-63.682*** (-8.13)
SaleGrowth	-0.004 (-1.49)	3.348* (1.68)	-0.005* (-1.71)	2.633 (1.39)
MTB	0.001*** (10.02)	0.980*** (4.50)	0.001*** (8.23)	0.811*** (3.73)
OpCash	-0.075*** (-7.52)	-50.685*** (-6.01)	-0.068*** (-6.72)	-41.275*** (-5.03)
Loss	-0.001 (-1.46)	0.807 (1.07)	-0.001 (-1.29)	0.887 (1.22)
Big4	0.007*** (5.36)	5.358*** (4.86)	0.007*** (5.15)	5.907*** (5.13)
SGA	-0.052*** (-8.64)	-73.055*** (-9.97)	-0.036*** (-5.50)	-64.172*** (-8.56)
Cash	0.093*** (21.31)	89.930*** (15.04)	0.084*** (18.58)	81.684*** (14.19)
FinCash	-0.034*** (-8.50)	-11.724*** (-3.21)	-0.035*** (-9.20)	-12.179*** (-3.59)
CapX	0.077*** (9.30)	37.007*** (5.51)	0.075*** (9.24)	33.548*** (5.17)
PPE	-0.006*** (-3.31)	-13.286*** (-6.05)	-0.010*** (-5.66)	-23.454*** (-7.69)
Constant	0.032*** (6.12)	-1.799 (-0.43)	0.020*** (3.70)	-0.095 (-0.02)
Industry Indicators	Yes	Yes	Yes	Yes
Year Indicators	Yes	Yes	Yes	Yes
Observations	28,825	28,825	28,825	28,825
Adjusted R^2	0.5926	0.4398	0.6301	0.4773

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 6
CEO Power and R&D Investment
Change Analysis

	Column 1	Column 2
	Dep. Var. = ΔRD	Dep. Var. = ΔRDEmpl
ΔCPS	**-0.008*****	**-0.608**
	(-5.24)	**(-0.55)**
ΔAGE	0.000	0.055
	(1.22)	(0.94)
ΔTENURE	-0.000	-0.042
	(-0.60)	(-0.10)
ΔCOMP	0.000***	0.081
	(10.38)	(1.60)
ΔReal_EM	-0.067***	-48.212***
	(-36.78)	(-4.49)
ΔlnTA	-0.018***	-1.364
	(-16.88)	(-0.62)
ΔAd	-0.162***	-63.339**
	(-13.01)	(-1.98)
ΔLEV	0.001	6.581
	(0.50)	(1.26)
ΔROA	-0.052***	-17.313***
	(-38.33)	(-3.84)
ΔSaleGrowth	-0.001***	-1.195
	(-2.73)	(-1.38)
ΔMTB	0.000	0.001
	(1.64)	(0.49)
ΔOpCash	-0.125***	-17.713**
	(-50.02)	(-2.36)
ΔLoss	-0.004***	1.568*
	(-7.87)	(1.91)
ΔBig4	-0.003	1.514
	(-1.50)	(0.79)
ΔSGA	0.098***	8.014
	(29.32)	(0.39)
ΔCash	-0.001	7.166
	(-0.33)	(1.22)
ΔFinCash	-0.028***	-8.554***
	(-17.67)	(-2.84)
ΔCapX	0.053***	7.689
	(9.08)	(1.15)
ΔPPE	0.006	-9.361*
	(1.29)	(-1.69)
Constant	0.000	-1.048*
	(0.14)	(-1.71)
Industry Indicators	Yes	Yes
Year Indicators	Yes	Yes
Observations	25,127	25,127
Adjusted R^2	0.3295	0.0781

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 7
CEO Power and R&D Investment
2SLS Test for Endogeneity

	Column 1	Column 2	Column 3
	Dep. Var. = CPS	Dep. Var. = RD	Dep. Var. = RDEmpl
lagCPS	**0.353***** **(73.28)**		
Ind_Year_Median_CPS	**0.564***** **(9.25)**		
Predicted_CPS		**-0.021***** **(-4.31)**	**-16.861***** **(-3.75)**
AGE	-0.001*** (-6.67)	-0.000*** (-5.83)	-0.140*** (-4.94)
TENURE	0.001 (0.66)	0.002*** (4.20)	1.357*** (3.36)
COMP	0.012*** (75.03)	0.002*** (18.00)	1.086*** (13.62)
Real_EM	-0.004 (-0.96)	-0.108*** (-74.20)	-67.076*** (-49.84)
lnTA	0.015*** (30.14)	-0.001*** (-4.75)	0.395** (2.09)
Ad	0.045* (1.93)	-0.287*** (-34.04)	-142.651*** (-18.27)
LEV	0.050*** (10.84)	-0.034*** (-19.90)	-13.244*** (-8.40)
ROA	0.074*** (7.75)	-0.112*** (-32.64)	-63.154*** (-19.82)
SaleGrowth	-0.024*** (-8.98)	-0.005*** (-5.17)	2.460*** (2.77)
MTB	-0.002*** (-10.81)	0.001*** (20.06)	0.797*** (14.25)
OpCash	0.040*** (3.89)	-0.068*** (-18.49)	-41.075*** (-12.11)
Loss	-0.004* (-1.91)	-0.001 (-1.55)	0.911 (1.35)
Big4	0.001 (0.59)	0.007*** (7.46)	5.766*** (7.11)
SGA	-0.043*** (-8.10)	-0.037*** (-18.87)	-64.644*** (-35.95)
Cash	-0.076*** (-16.04)	0.083*** (47.54)	81.187*** (50.00)
FinCash	0.005 (0.79)	-0.035*** (-14.76)	-12.199*** (-5.55)
CapX	-0.137*** (-7.99)	0.073*** (11.70)	32.024*** (5.56)
PPE	0.015*** (3.05)	-0.010*** (-5.42)	-23.124*** (-14.10)
Constant	-0.159*** (-6.22)	0.026*** (5.74)	4.648 (1.13)
Industry Indicators	Yes	Yes	Yes
Year Indicators	Yes	Yes	Yes
Observations	28,825	28,825	28,825
Adjusted R^2	0.3465	0.6291	0.4760

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Table 8
CEO Power and R&D Investment
The Role of Corporate Governance

	Column 1	Column 2
	Dep. Var. = RD	Dep. Var. = RDEmpl
CPS	**-0.019*****	**-19.753*****
	(-6.08)	**(-5.52)**
EI	0.013*	10.932
	(1.83)	(1.41)
CPSxEI	**-0.033****	**-31.216***
	(-2.11)	**(-1.76)**
AGE	-0.000***	-0.215***
	(-4.71)	(-4.03)
TENURE	0.002**	0.722
	(2.42)	(0.96)
COMP	0.001***	1.558***
	(11.13)	(10.72)
Real_EM	-0.142***	-115.248***
	(-59.11)	(-42.60)
lnTA	-0.002***	1.256***
	(-5.59)	(3.92)
Ad	-0.428***	-277.692***
	(-34.84)	(-20.10)
LEV	-0.035***	-21.015***
	(-13.68)	(-7.41)
ROA	-0.070***	-50.741***
	(-11.51)	(-7.46)
SaleGrowth	-0.004**	7.775***
	(-2.15)	(3.86)
MTB	0.001***	1.091***
	(14.38)	(11.02)
OpCash	-0.053***	-48.455***
	(-8.31)	(-6.81)
Loss	0.004***	7.083***
	(3.57)	(5.22)
Big4	0.007***	7.846***
	(6.23)	(5.82)
SGA	-0.076***	-107.288***
	(-23.31)	(-29.12)
Cash	0.077***	99.581***
	(28.73)	(32.90)
FinCash	-0.049***	-21.890***
	(-12.71)	(-5.02)
CapX	0.073***	48.278***
	(7.36)	(4.34)
PPE	-0.009***	-18.167***
	(-4.15)	(-7.36)
Constant	0.045***	0.073
	(8.20)	(0.01)
Industry Indicators	Yes	Yes
Year Indicators	Yes	Yes
Observations	10,924	10,924
Adjusted R^2	0.5779	0.4317

*, **, and *** denote significance at the 10, 5 and 1 percent (two-tailed) confidence levels, respectively.
T-values are stated in parentheses.

Endnotes:

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[1] https://www.strategy-business.com/feature/What-the-Top-Innovators-Get-Right?gko=bdbc7

[2] "*CEOs keenly feel the tension between focusing on the disruptive future and running the current business (e.g., managing stakeholders, operations, sales, etc.). This may explain why 52% of CEOs said that their corporate priorities were weighted toward optimizing revenues from current business models...*" (EY, 2017)