2019

Does Managerial Risk-Taking Incentive for R&D Investments Translate to Future Earnings?

Ha Yun Cho

Recommended Citation

Cho, Ha Yun, "Does Managerial Risk-Taking Incentive for R&D Investments Translate to Future Earnings?" (2019). *CMC Senior Theses*. 2199.
https://scholarship.claremont.edu/cmc_theses/2199

Claremont McKenna College

Does managerial risk-taking incentive for R&D investments translate to future earnings?

submitted to
Professor George Batta

by
Ha Yun Cho

for
Senior Thesis
Spring 2019
April 29th, 2019

This page is left intentionally blank

Acknowledgements

First and foremost, I would like to give all my thanks to you, my Heavenly Father. Without your spiritual guidance and direction, I would not be where I am today. You have satisfied my needs in a sun-scorched land, and you have blessed me with wonderful people along this journey at Claremont McKenna College.

I would like to acknowledge Professor George Batta for his support and encouragement throughout the process. Your advice and direction have been incredibly valuable, and I cannot thank enough for all the time you spent with me when I faced challenges with my data.

I would also like to thank all my friends I have made in Claremont — I am blessed to know so many talented and amazing individuals. You all have inspired and encouraged me throughout my four-years at college, and I am so thankful to have great stories and memories to share about the times that we had together.

Lastly, I would like to acknowledge and dedicate my Senior Thesis to my parents in Korea. Without your continuous support and unconditional love, I would not be where I am today. You both have provided me with tremendous amount of opportunities that I could have in my life, and I am deeply grateful for all what you have done for me. Thank you for being my spiritual mentor during my four-years at college — I could have not made it without your prayers.

Abstract

The convex pay-off structure of executive stock options (ESO) incentivizes CEOs to increase their firm stock-return volatility, thereby increasing their wealth in option portfolio. In this paper, I address two research questions. I first test if this managerial incentive induces executives to take on more risky projects in R&D that increases stock-return volatility, hence, boosting their personal wealth. I derive *vega* to measure managerial incentive, and *vega* is a dollar change in ESO for a 0.01 change in stock-return volatility. I find that there is a positive and statistically significant relationship between *vega* and R&D investment, which suggests that managers whose wealth is closely tied to stock options are more incentivized to invest in risky R&D projects to increase their wealth and stock-return volatility. This result is statistically significant and robust after adjusting for inflation and controlling for firm and industry-fixed effects. With this finding, I proceed to test if managerial risk-taking incentive for R&D investments translate to future earnings. Lev and Sougiannis (1996) establish that future earnings is a function of both tangible and intangible assets, and R&D increases with firm's subsequent earnings. Since R&D spending changes with managerial incentive, I test if the interactive variable of *vega* and R&D has a positive effect on firm's future earnings. I find that managerial incentive for undertaking R&D investments has a positive and statistically significant association with future earnings under industry-fixed effects specifications. When controlling for firm-fixed effects, the result yielded similar results to that of industry-fixed effects, but with less statistical significance. Lastly, for robustness check, I run the regression with a balanced panel data of tenured-CEOs, who stay with the firm for five years. I find that the result is positive and statistically significant for industry-fixed effects. However, for firm-fixed effects, I only find statistical significance at year $t_{+k\ (k=3).}$ This suggests that the realization of R&D investment to future earnings is not prevalent throughout all years when R&D decisions are made by incentivized, long-standing CEOs.

Table of Contents

I. Introduction

Traditional compensation policy in salary, bonus, and stock incentivizes managers to be more risk-averse and turn down risk-increasing projects. Nowadays, more executives are compensated in executive stock options (ESO), which addresses agency problems and encourage risk-averse managers to invest in high-risk high-reward projects (Jensen and Meckling, 1976). The convex payoff structure of stock options allows the option value to increase with stock-return volatility, and Cohen et al. (2000) find that as managers increase their option holdings, they are more incentivized to take actions that increase subsequent firm risk. This result supports the theory established by Guay (1999), in which he claims that as manager's wealth is more sensitive to stock-return volatility, the manager is more incentivized to engage in investment and financing decisions. This sensitivity measurement is denoted as *vega*, which measures the managerial incentive to take on risks.

This paper attempts to address two research questions. I first examine how managerial incentive for taking on risky projects associates with R&D spending. Existing literature has established that managers with ESO are more incentivized to increase equity volatility, and one of the ways to do so is by investing in risky projects (Coles et al., 2006). I test if managerial incentive increases with R&D expenditures, which is considered to be riskier than investments in property, plant, and equipment (Coles et al., 2006). I expand the existing literature by testing if the association between R&D and managerial incentive continues to be positive for a broad sample of 2,276 firms from various industries, over a more recent time period of 1992 to 2018.

I obtain all the data from Wharton Research Data Services. I use Compustat, Execucomp, and CRSP. I follow the study done by Coles et al. (2006) that calculates the dollar value of *vega* and *delta* from 1992 to 2002, controlling for firm and industry-fixed effects. *Delta* is the ESO slope effect, which explains a manager's incentive to take on positive NPV projects that increase equity price (Rajgopal and Shelvin, 2002). I take methodology of Coles et al. (2006) and derive CEO's *vega* and *delta* from 1992 to 2018. With these values, I regress R&D spending, scaled by total assets, with respect to *vega* and control for *delta* and firm characteristics such as capital expenditures, size, leverage, Tobin's Q, sales growth, and free cash flow level. I find that manager's incentive for risk-taking increases with R&D intensity. In other words, managers who hold ESOs are more incentivized to take on R&D projects to raise firm volatility, hence, increasing their wealth in options. This positive relationship is highly statistically significant but yielded small economic significance. The result, however, still remained robust, even after adjusting *vega* and *delta* to the price-level in 2018.

After establishing this association, I conduct a second study to analyze if a manager's incentive for taking on projects in R&D translate to increase in future earnings. Lev and Sougiannis (1996) and Sougiannis (1994) find that R&D investments are positively correlated with subsequent earnings, and from my first research question, I establish that managerial incentive for risk increases with R&D spending. Therefore, I hypothesize that the interactive variable of R&D and *vega*, which measures manager's incentive for risk-taking specifically on R&D projects, would positively affect future earnings. To my knowledge, this has not been explicitly addressed by previous studies. Lev and Sougiannis (1996) predict subsequent earnings by only including R&D, and Hanlon et al. (2003) include the dollar value of ESO, which does not factor in manager's incentive on investment decisions. Therefore, I expand from the previous literatures by adding in the interactive variable of *vega* and R&D, which captures managerial incentive for R&D projects.

Operating income of a firm is a production function of both tangible and intangible assets (e.g., Lev and Sougiannis, 1996; Hanlon et al., 2003). Therefore, I regress operating income at $t_{+k\ (k=0-5)}$ on tangible assets that include inventories and property, plant, and equipment and intangible assets that include R&D spending, *vega*, and interactive variable of R&D and *vega*. All variables but *vega* are scaled by total assets, and all variables but operating income are lagged by one year. I run two separate regressions, respectively controlling for firm and industry-fixed effects. For robustness check, I correct for survivorship bias and run the model on a balanced panel data of tenured-CEOs, a selective group of long-standing CEOs who stay with the firm for five years.[1] By doing so, I also test how tenured-CEOs' incentive for taking on R&D projects translate to future earnings, specifically narrowing my focus to CEOs who shepherd the R&D investment until the future earnings are realized.

When I run this regression on a balanced panel data, controlling for firm and industry-fixed effects, I find that managerial incentive for R&D investment increases firm's future earnings. Put differently, a manager's decision to increase firm volatility by undertaking R&D projects, not only leads to an increase in personal wealth but also firm's earnings. Specifically, when controlled for industry-fixed effects, I discover this relationship to be statistically significant for all years $t_{+k\ (k=0-5)}$. However, when controlling for firm-fixed effect, statistical significance is only shown at year t_{+3}. This result suggests that long-standing executives' incentive for R&D projects translates to

---

[1] Equilar Inc. (2018) published a study that shows five-year is an average tenure for CEOs at S&P 500 companies.

significant increase in future earnings, three years after their investment. It also implies that stock-return volatility does not incentivize tenured-CEOs decision on R&D investments, and perhaps they use R&D investments only as a means to increase their own personal wealth. This implication is supported by the negative and statistically significant result of the *vega* coefficients for years $t_{+k\,(\mathrm{k} = 2 - 5)}$.

The rest of the paper is organized as follows. Section II reviews the related literature. Section III develops my research hypotheses. Section IV discusses the data and methodology for deriving *vega* and *delta*. Section V presents empirical strategy and results. The conclusions are presented in Section VI.

II. Literature review

Early research shows that R&D investments are positively correlated with subsequent earnings (e.g., Lev and Sougiannis, 1996; Sougiannis 1994). However, Porter (1992) finds that sometimes managers cut R&D investments to meet short-term earnings goals, instead of creating a long-term corporate value. The U.S. corporate system puts responsibility on firms to maximize shareholder value, and Porter (1992) argues that this environment predominantly pressures managements to sacrifice R&D investments in order to maintain short-term earnings and stock performance goals. This investment decision behavior is called "managerial myopia," where managers underinvest in long-term intangible projects such as R&D, advertising, and employee training, for the purposes of meeting short-term goals (Porter, 1992). Investors cannot see beyond the current earnings, and this myopic view leads managers to avoid investments with long-term payouts, believing that such spending will reduce short-term earnings and stock prices. Dechow and Sloan (1991) confirm this behavior especially for CEOs during their final year in executive positions — CEOs invest less in R&D projects during their final term. However, this myopic investment decision is mitigated when companies have a high percentage of institutional ownership. Bushee (1998) finds that these sophisticated institutional investors actually encourage companies to focus on driving long-term values through investments in R&D rather than immediate short-term gains.

However, for companies that face declines in earnings, investment in R&D could actually help them. Chan et al. (1990) discover that when companies make new R&D project announcements, the market positively incorporates this new information into their stock prices. This reaction suggests that investors also positively view R&D as a long-term value-creating investment, which encourages them to look further beyond the short-term earnings and myopic investment horizon. Chan et al. (1990) find that this behavior, however, only applies to technologically mature companies. They conclude that for low-technologically mature companies, the market reacts negatively when they announce R&D expenditures. This result indicates that R&D spending matters differently for each industry and the maturity of each company. Johnson and Pazderka (1993) also confirm this association with companies listed on the Canadian stock market.

Managers are primarily incentivized to make decisions that maximize shareholders' value and meet earnings expectations. However, when executives get compensated through stock options, they also make decisions that increase their wealth. Bergstresser and Philippon (2006) find this relation to be true by testing the association between employee stock options and earnings manipulation. They find that CEOs use discretionary accruals to manipulate reported earnings when their potential total compensation is closely tied to the value of stock and option holdings. Put differently, earnings management is more prevalent at firms that have incentivized CEOs, whose compensation is sensitive to companies' share prices. Ali and Zhang (2015) discover that CEOs are more incentivized to manage earnings in their earlier years when the market perception is more uncertain. They find that, on average, CEOs use discretionary accruals like R&D expenses to overstate returns on assets by 25% in earlier years of their CEO terms (Ali and Zhang, 2015). However, for firms that have strong internal and external monitoring through board and audit committee independence, this difference in earnings overstatement is less pronounced.

Jensen and Meckling (1976) claim that stock option compensation policy allows shareholders to reduce agency conflict with managers and encourages executives to take actions which increase equity value. Option value increases with volatility, and Cohen et al. (2000) find that managers who hold executive stock options are more incentivized to take actions that increase firm risk. They find a statistically significant and positive relationship between increase in option holdings and subsequent firm risk. Guay (1999) claims that the sensitivity of a manager's wealth to the volatility of the equity value significantly affects managerial decision for investment and financing choices. This sensitivity is called *vega*, which measures the change in option portfolio value for a 0.01 change in stock-return volatility. Core and Guay (2002) establish an easy-to-implement alternative method to compute managerial incentives by taking a partial derivative of the Black-Scholes option value with respect to stock price. By doing so, they also define *delta*, which is the changes in the dollar value of executive stock options for a one percentage change in stock price. Unlike Guay (1999) and Core and Guay (2002) who define *vega* and *delta* from partial derivatives, Rajgopal and Shelvin (2002) assert that *delta* explains a manager's incentive to take on positive NPV projects that increase equity price, whereas *vega* measures managerial incentive to increase stock return volatility by becoming involved in risky projects.

Managerial incentives also have an effect on future operating income. Lev and Sougiannis (1996) predict subsequent earnings by defining operating income as a production function of tangible and intangible assets. Hanlon et al. (2003) follow this methodology and estimate the link between future operating income and the Black-Scholes value of ESO grants to the top five executives. They test to see if the association between future earnings and ESO grants given to the top five executives explains executives' investment alignment and option granting behavior. Their results show that a dollar of Black-Scholes value of an ESO grant is associated with future operating income by $3.71.

In this paper, I address if the managerial incentive for taking on R&D projects translates to future earnings. I expand the existing literature by adding managerial incentive into the earnings function. To account for intangible assets, Lev and Sougiannis (1996) include R&D, and Hanlon et al. (2003) add the dollar value of ESO, which does not capture managerial incentive on investment decisions. However, I include the sensitivity of the value of ESO on stock return-volatility (*vega*), R&D, and the interactive variable of *vega* and R&D to factor in the effects that managerial incentive has on R&D investments.

III. Hypotheses

1. Relationship between R&D spending and Vega

As Guay (1999) establishes, the convex payoff structure of options makes the value of a manager's stock option portfolio increase with the firm's volatility on stock-returns. Executives can increase stock-return volatility by taking on risky projects or increasing firm leverage, and generally R&D investments are considered high-risk investments compared to capital expenditures on property plant and equipment (Coles et al. 2006). Coles et al. (2006) find a strong causal link between managerial compensation and investment policy, debt policy, and firm risk. They conclude that high sensitivity of CEO wealth to stock-return volatility induces managerial choice to take on more and higher leverage and invest less in property, plant, and equipment. Therefore, I hypothesize that:

> H1: *Ceteris paribus*, as the sensitivity of executive's stock option portfolio to stock return volatility (*vega*) increases, managers take on more risky projects such as R&D.

2. Relationship between future earnings, Vega, and R&D

Lev and Sougiannis (1996) establish that R&D investments are positively associated with subsequent earnings. Future earnings can be derived by a production function of tangible and intangible assets (Lev and Sougiannis, 1996; Hanlon et al., 2003). R&D is included as intangible assets, but R&D can change with managerial incentive when executives get ESO compensation. Hanlon et al. (2003) find that ESO compensation has a positive effect on future operating income. They test to see if the association between ESO grants given to the top five executives and future earnings explains the executives' investment alignment and option granting behavior. They find that, on average, a dollar of Black-Scholes value of an ESO grant is associated with future operating income by $3.71. However, they test in dollar value terms, which does not incorporate managerial incentive. Therefore, by including *vega*, I assess if managerial incentive for risk-taking in R&D projects associates with future earnings. I hypothesize that:

> H2: *Ceteris paribus*, the interaction of *vega* and R&D spending has positive relationship with future operating income and has explanatory power in predicting future operating income.

I expect to find a positive and statistical relationship for the following reasons. First, *vega* measures managerial incentive for increasing firm risk, and managers can increase volatility by taking on risky projects. R&D projects are high-risk and high-return projects, and their payouts are in the long-term. Therefore, when managers choose to invest in risky R&D projects, I hypothesize that they make this decision with an expectation that R&D investment would increase both firm risk and future earnings. For this reason, I expect that managerial incentive for undertaking R&D investments positively affects future earnings to be realized.

IV. Data

I obtain all the data from Wharton Research Data Services. I use Compustat, Execucomp, and CRSP. Compustat provides firm-level annual financial statement data; Execucomp compiles annual salary, bonus, and total compensation for the top five executives; and CRSP database offers monthly historical stock prices.

The sample includes current CEOs' stock option compensations and firm-specific financial data for fiscal years 1992-2018. I restrict my analysis to only current CEOs because I assume that managerial decisions for R&D investment is made at the CEO-level. Moreover, the top five executives change year to year, since they are ranked annually by salary and bonus. Therefore, even if I assume that R&D investment is collectively decided by the top five executive-level, for consistency, I restrict my data to only CEO-level.

Execucomp changed its data reporting format in 2006, which reflected new accounting changes made by the Financial Accounting Standards Board (FASB) and additional equity-based compensation disclosures imposed by the Securities and Exchange Commission (SEC). For this reason, derivation for *vega* and *delta* is different for pre and post-2006.

1. Derivation for *vega* and *delta*

Vega measures pay-performance sensitivity in manager's stock option portfolio for a 0.01 change in stock-return volatility. It numerically quantifies manager's incentive to increase stock-return volatility. To calculate *vega*, I follow Guay (1999), Core and Guay (2002), and Coles et al. (2006) methodologies, which use Black-Scholes (1973) option pricing model with a modification made by Merton (1973) that includes dividends.[2] Black-Scholes formula for valuing call options with Merton (1973)'s modification is as follows:

$$\text{Option value} = [Se^{-dT}N(Z) - Xe^{-rT}N\left(Z - \sigma T^{(1/2)}\right)] \tag{1}$$

where Z is $\left[\ln{(S/X)} + T\left(r - d + \frac{\sigma^2}{2}\right)\right]/\left(\sigma T^{(1/2)}\right)$, N is the cumulative probability function for normal distribution; S is the price of underlying strike; X is the exercise price of the stock option; σ is the estimated stock-return volatility over the option maturity; r is the risk-free rate; T is the time to maturity of the option in years; and d is the expected dividend rate over the life of the option.

To compute *vega*, I take partial derivative of the option value with respect to 0.01 change in stock-return volatility as follows:

$$\frac{\partial(Option\ value)}{\partial(stock\ volatility)}\times 0.01 = e^{-dt}N'(Z)ST^{(1/2)}\times 0.01 \tag{2}$$

where N' is a normal density function and all other variables are as previously defined.

Delta measures pay-performance price sensitivity, which is a change in dollar value of executive's stock option for a one percentage point change in stock price. I take partial derivative of the option value with respect to a 1% change in stock price:

$$\frac{\partial(Option\ value)}{\partial(stock\ price)}\times\frac{price}{100} = e^{-dt}N(Z)\times\frac{\text{price}}{100} \tag{3}$$

where N is a normal density function and all other variables are as previously defined.

To compute the pay-performance sensitivity, I need the following inputs from Execucomp to first calculate the Black-Scholes option value: number of vested and unvested option awards, exercise price, expiration date of option, and stock price at fiscal year-end. I estimate stock-return volatility and dividend yield, using Coles et al. (2006)

---

[2] For detailed explanation on how to compute *vega* and *delta* using Compustat, Execucomp, and CRSP, refer to Coles et al. (2013).

methodology. I retrieve data for historical risk-free rates from the Federal Reserve website and correspond to the maturity of the options.

The major difference between the pre and post-2006 reporting is the absence of tranche-level details for previous years' option grants. Starting from 2006, Execucomp provides information for each outstanding option tranche such as the number of vested, number of unvested, and unearned options. It also provides the exercise price and expiration date for each corresponding option tranche. All this information is conveniently located in one dataset called "Compustat Executive Compensation – Outstanding Equity Awards." However, for periods before 2006, the primary database (Company Financial and Director Compensation) only offers details for current year outstanding options. The exercise price and the expiration date are provided from different datasets: 1) Stock Option Grants and 2) Annual Compensation. For this reason, to calculate *vega and delta* for pre-2006, I merge three different datasets: Company Financial and Director Compensation, Stock Option Grants, and Annual Compensation, and I estimate the vested and unvested option values that exclude current year option grants.

For post-2006, calculating *vega and delta* is simply inputting the corresponding variables to the Black-Scholes option model then taking a partial derivative with respect to either stock-return volatility or stock price. All the information is given in the dataset except stock-return volatility, dividend yield, and risk-free rates. As of 2006, Execucomp discontinued providing stock- return volatility. I follow methodologies of Execucomp and Coles et al. (2006) and use annualized standard deviation of the historical monthly stock returns, which is estimated 60 months prior to the beginning of the fiscal period. For samples that have less than 12 months of data, I take the mean volatility. Finally, I winsorize the volatility estimates at the 5th and 95th percentile levels. Execucomp also stopped providing dividend yield as of 2006. Similar to how I estimate stock-return volatility, I estimate the dividend yield using the same methodology from Execucomp and Coles et al. (2006). I take average of the current and two prior years of dividend yield and winsorize it at the 5th and 95th levels. For risk-free rates, I obtain data from the Federal Reserve website, which offers sample points for one, two, three, five, seven, and ten-year Treasury securities. For four, six, eight, and nine-year Treasury securities, I follow Coles et al. (2006) and interpolate the rates. For maturities that are more than ten-years, I use the ten-year rate.

For pre-2006 samples, I use the same approximation method for post-2006. However, because detailed information is only provided for the current year option tranche and not for options from previous years, I estimate values using methodology from Core and Guay (2002) and Coles et al. (2006).[3] To compute the number of previously granted unvested options, Coles et al. (2006) estimate unvested number of options excluding current year by subtracting the number of options granted in the current year from the number of unvested options.

Lastly, when estimating maturity for these previously granted unvested options, I follow Coles et al. (2006) methodology by subtracting one from the maturity year of current year options grants. For options that do not have current year grants, I assume the average maturity of these previously granted unvested options to be nine years. Following Core and Guay (2002) and Coles et al. (2006), I compute the maturity of vested options by subtracting three years from the maturity of unvested options.

---

[3] For detailed explanation on how to compute *vega* and *delta* using Compustat, Execucomp, and CRSP, refer to Coles et al. (2013).

Using all these inputs, *vega* is the sum of current year options *vega* and *vega* of previously-granted vested and unvested options. Likewise, *delta* is estimated by summing the *delta* of current year options, the *delta* of the portfolio of previously-granted unvested and vested options, and the *delta* from the shares owned by the executive.

2. Summary Statistics

Table 1 represents summary statistics of executive compensation and firm characteristics data from 1992 to 2018. The sample consists of 2,636 firms and 27,266 of total observations over sample period time of 1992 to 2018. *Vega* represents the dollar change in executive's option wealth for a 0.01 change in stock-return volatility. *Delta* is the dollar change in executive's option wealth for a 1% change in stock price. Consistent with prior literature (Guay, 1999; Core and Guay, 1999; Coles et al., 2006) *vega and delta* are winsorized at the 1st and 99th percentile level. Mean (median) *vega* is $119,000 ($45,000) and mean (median) *delta* is $576,000 ($194,000). R&D is expenditures on research and development scaled by total assets. Size represents the market value of the firm at fiscal year-end. Leverage is the aggregate of long-term and current liability, scaled by total assets. Tobin's Q is a ratio of enterprise value to total assets. Free cash flow level is derived by operating income before depreciation net of capital expenditures, scaled by assets.

V. Empirical Strategy and Results

1. Relationship between R&D spending and managerial incentive

To test whether managers' sensitivity to stock-return volatility incentivizes them to invest in R&D projects, I use a multivariate panel regression model to regress R&D spending scaled by total assets on *vega*.[4] I also use a set of control variables that represents firm characteristics and affects R&D investment. I control for time-fixed effects to capture the influence of time-series trends. I also run two separate regressions, fixing for either firm or industry-fixed effects. I cluster my standard errors at a firm-level, controlling for time-series error correlation for each panel.

$$R\&D_{it} = \alpha + \beta_1 Vega_{it} + \beta_2 Delta_{it} + \beta_3 X_{it} + \varepsilon_{it} \qquad (4)$$

where R&D is R&D expenses scaled by total assets, *i* and *t* represent firm and year, X is a vector of firm characteristic control variables (defined below), and ε is an error term with the usual properties.

1) *Control Variables*

I use a set of control variables to capture the effect of omitted variable bias that would affect R&D spending. I choose these variables based on existing literature (e.g., Bushee, 1998; Bergstresser and Philippon, 2003; Coles et al., 2006). I first control for *delta*. *Delta* measures a manager's incentive for a one percentage change in stock price. A manager's wealth is tied to the stock price, which would decrease his willingness to bear risk (Knopf et al., 2002). Moreover, managers under invest in long-term intangible projects to meet short-term earnings expectations (e.g., Porter, 1992; Dechow and Sloan,

---

[4] For firms that have missing R&D data, I set R&D equal to zero.

1991; Johnson and Pazderka, 1993; Chan et al., 1990). Therefore, I control for this risk-aversion for changes in stock price to capture the pure effect of managerial incentive for risk-taking: *vega*. Second, I control for *CAPEX (capital expenditures)*, scaled by total assets. Companies have a choice to invest in tangible and/or intangible investments. Tangible investments include capital expenditures on property, plant, and equipment, which are considered less risky than intangible projects such as R&D (Coles et al., 2006). Therefore, I include *CAPEX* to control for manager investment decision effect. Third, I add a *Size* variable, which is the logarithm of market value of equity, to control for a firm's size effect. The R&D spending level will vary by firm size. I predict that *Size* will have a positive association with R&D spending, for large-companies would have more available funds to finance R&D investments. Fourth, I include *Leverage* to control for the effect of companies' debt covenant incentive for risky projects and earnings management. Fifth, I follow Bergstresser and Phillippon (2006) and add Tobin's Q to capture the effect of marginal benefit-to-cost ratio for a new investment. I expect a positive link between Tobin's Q and R&D intensity based on the prior literature (Hirschey and Weygandt, 1985). Sixth, I include *Sales Growth,* a logarithm of the ratio of current year sales to previous year sales. Lastly, I include *Free Cash Flow Level*, which is the operating income before depreciation net of capital expenditures, scaled by assets. This variable captures the effect of near-term financing requirements (Bushee, 1998).

2) *Result*

Table 2 represents the regression result of R&D on CEO incentive. The estimated coefficients for *vega* are statistically significant at the both 5% and 1% level, when controlled for either firm or industry-fixed effects.[5] The *vega* coefficient is positive, which indicates that higher *vega* is associated with higher R&D expenditures. This finding suggests that as CEOs' wealth is more sensitive to stock-return volatility, those CEOs are more incentivized to take on risky projects in R&D to increase firm risk, hence, boost their wealth in option portfolio. This regression result is statistically significant, after controlling for the negative and statistically significant effect of *delta* on R&D and other firm-characteristic control variables.

The negative relationship between delta and R&D implies that as executives' wealth sensitivity increases with stock price, executives take on less risky investments. Therefore, by controlling for *delta*, I find that managerial incentive for assuming risk explain firm's R&D intensity, above and beyond the effect of *delta*. Under industry-fixed effect specifications, *CAPEX, Size,* and *Leverage* all have a negative and statistically significant association with R&D. The negative link between *CAPEX* and R&D explains that when CEOs decide to increase investments in capital expenditures, they reduce their willingness to take on R&D projects. In other words, CEOs make additional investment decisions that are either in R&D or *CAPEX*. One possible explanation for the negative relationship between *Size* and R&D is that small firms in development and growing stage assume the risk of R&D projects to build competitive advantage against their peers, seeking for more growth opportunities. Put differently, these small-sized firms see R&D as a long-term growth-enhancing investment. *Leverage* also negatively affects R&D spending, which suggests that higher debt covenant reduces managerial incentive for risky investments and earnings management. Lastly, the negative relationship between

---

[5] Consistent with prior literatures (e.g., Coles et al., 2006; Hanlon et al., 2003), I included all industries except financial services and utilities.

free cash flow level and R&D explains why companies cut R&D spending when they face more near-term financing requirements.

For robustness check, I adjust *vega* and *delta* at the price-level in 2018. Appendix 1 shows that the results are still statistically significant for both firm and industry-fixed effects, which suggest that even after adjusting for inflation, the effect of managerial incentive for risk-taking has a positive effect on firm's decision on R&D investments.

The results for firm-fixed effects are slightly weaker than those of the industry-fixed effects. This is plausible when an individual company shows a relatively constant trend in *vega* over a sample time period. Therefore, firm-fixed effects weaken the explanatory power of *vega* on R&D when each firm has less variation in *vega*. Although the positive result of *vega* shows there is a statistically significant association between R&D spending and *vega*, there is little economic importance. The coefficients for both firm and industry-fixed effects are close to zero, which implies that the economic significance is minuscule. As seen in Table 1, under an industry-fixed effect, the *vega* coefficient of 0.0239 indicates that for every million-dollar change in an executive's wealth for a 0.01 change in stock-return volatility, the R&D intensity level increases by 0.0239%. Notice that in Table 1, the standard deviation for *vega* is $198,000. Therefore, on average, the effect of *vega* affecting the R&D intensity level would be much smaller than 0.0239%.

2. Relationship between future operating income and *vega* and R&D

To test if managerial incentive for accepting R&D projects translate to a realization in future earnings, I follow methodologies of Lev and Sougiannis (1996) and

Hanlon et al. (2003). Lev and Sougiannis (1996) establish that operating income (OI_{it}) is a function of tangible (TA_{it}) and intangible assets (IA_{it}) of a firm *i* in year *t*:

$$OI_{it} = f\,(TA_{it}, IA_{it}) \tag{5}$$

where OI is operating income scaled by sales, TA is tangible assets scaled by sales, IA is intangible assets, and *i* and *t* represent firm and year.

Data for operating income and tangible assets is readily available on Compustat. Tangible assets include inventories and property, plant, and equipment. Hanlon et al. (2003) scale operating income and tangible assets by sales. However, I scale these variables by total assets because total assets are less volatile than sales, thereby yielding more stable measurements. R&D is included as intangible assets. However, a firm's R&D intensity changes with managerial incentives when executives hold ESOs. Hanlon et al. (2003) estimate intangible capital using Black-Scholes ESO values, with the assumption that the dollar value of ESO would affect a firm's decision on intangible investments. Hanlon et al. (2003) take this dollar value, not factoring in the sensitivity of an executive's option portfolio to a change in stock price or stock-return volatility. They argue that they do this because their focus is not understanding how an executive's incentive-intensity relates with operating income. Instead, they claim that they are interested in isolating the cost-benefit of ESOs on operating income, hence, they use the dollar value terms and not *vega* or *delta*. However, for my study, I use *vega* to account for the relationship between managerial incentive on R&D spending, which I establish in my first research question. Therefore, for intangible assets, I add R&D, *vega*, and an interactive term of *vega* and R&D to capture the effect of managerial incentives on R&D projects.

In my study, R&D is scaled by total assets. However, *vega* is not scaled and is in dollar terms because I assume that a dollar increase in an executive's wealth is equivalent for all executives irrespective of firm size. To predict future operating income, I set operating income at time $t_{+k\ (k = 0-5)}$, and I take all the independent variables lagged by one year, t_{-1}. R&D projects are long-term value-enhancing investments, which take time to bear fruit. To account for this characteristic, I regress operating income for year $t_{+k\ (k = 0-5)}$ to find the effect of lagged R&D and managerial incentive on long-term future earnings. Therefore, I estimate future earnings as follows:

$$OI_{i,t+k\ (k = 0\text{-}5)} = \alpha + \beta_1 Vega_{i,t-1} \times R\&D_{i,t-1} + \beta_2 Vega_{i,t-1} + \beta_3 R\&D_{i,t-1} + \beta_4 TA_{i,t-1} + \varepsilon_{i,t-1} \qquad (6)$$

where OI is operating income, scaled by total assets; R&D is R&D spending, scaled by total assets; TA is tangible assets that include inventories and property, plant, and equipment, scaled by total assets; *i* and *t* represent firm and year, and ε is an error term with the usual properties.

I control for time-fixed effects to capture the influence of time-series trends. I also run two separate regressions, fixing for industry and firm -fixed effects. I cluster my standard errors at a firm-level, controlling for time-series error correlation for each panel.

1) *Correlation matrix*

Table 3 reports a correlation between variables for my baseline regression at $t_{+k\ (k=0)}$. Each variable is statistically and significantly associated with one another, except the association between future earnings and the interactive variable of *vega* and R&D. *Vega* is positively correlated with future operating income, which indicates that a manager's incentive to take on risky projects increases with firm's future earnings. This positive association is also shown with future earnings and tangible assets. However, a negative correlation is shown between R&D and future operating income. This result suggests that investment in R&D does not translate to an immediate increase in future earnings. I expect this relationship to change its direction when future earnings are forecasted for a longer time horizon.

2) *Results*

Table 4 represents the regression result when controlled for firm-fixed effects. It shows that managerial incentive for R&D has a positive and statistically significant association with future operating income at year $t_{+k\ (k=0-3)}$. For every $t_{+k\ (k=0-5)}$, I restrict the sample to CEOs that survived at year $t+_{k\ (k=0-5)}$. The outcome proposes that when managers, who are incentivized to augment their wealth by increasing firm risk, invest in R&D projects, this investment decision translates to an increase in future earnings. However, under firm-fixed effects specifications, the positive value of R&D spending is not realized after year t_{+3}. Nonetheless, when controlling for industry-fixed effects, the association between future earnings and managerial incentive on R&D investment is positive and statistically significant for all years throughout $t_{+k\ (k=0-5)}$, as shown in Table 5.

There is a noticeable difference between the magnitudes of the variables when controlling for firm or industry-fixed effects, respectively. For example, the coefficient for $\text{Vega}_{i,t-1}\times\text{R\&D}_{i,t-1}$ under firm-fixed effects is in the range of 0.22 to 0.55, whereas under industry-fixed effects, it is in the range of 1.35 to 1.61. In other words, when controlling for industry-fixed effects, the interactive term of *vega* and R&D affects future earnings by approximately three to six-times greater than the model for firm-fixed effects specifications. That is to say, when I take each firm-specific characteristic into account, the effect of managerial incentive on R&D investment gets smaller, compared to when I lump the firms together by industries. Also, the results for industry-fixed effects show higher statistical significance than that of firm-fixed effects because managerial incentive for R&D is less variant over time for firm-fixed effects than it is for industry-fixed effects.[6]

Another noticeable difference between firm and industry-fixed effect is the coefficient sign of *vega* and its statistical significance. When controlled for industry-fixed effects, *vega* shows a positive association with future earnings and loses its significance at year t_{+4}. However, under firm-fixed effects, the results for *vega* and earnings show a negative association and present a statistical significance at year $t_{+k\ (k = 1 - 5)}$. Under industry-fixed effects, R&D has a negative relation to future earnings and has statistical significance for all projected years. However, when controlled for firm-fixed effects, R&D negatively associates with future earnings for firm-fixed effects, but the statistical significance is only shown at year t and t_{+2}.

One plausible explanation for this difference in coefficient signs and statistical significance is that by controlling for industry-fixed effects, the model lumps firms by their industries and does not control for omitted variable bias that each firm has in the model. Therefore, by forcing a firm-fixed effect specification, I control for factors that are unobserved or unmeasured and vary across firms but not over time. Although firm-fixed effects control for these factors at the lowest-level, I am cautious about concluding

---

[6] I have a choice to use firm or industry-fixed effect to test my model. The data has 2,461 unique firms and 10 industries. It is tempting to use firm-fixed effect over industry-fixed effect because by controlling for each 2,461 firm the model, it would present a higher explanatory power. However, there is a danger to this approach, especially when my parameter of interest is not time-variant at the firm level. By being firm-specific, I am allowing the result to lose its statistical significance. Therefore, for comparison, I present and analyze results for both firm and industry-fixed effect specifications.

that the firm-fixed effect model represents my empirical study better than an industry-fixed effect regression, especially when my parameter of interest is less time-variant. This is because by being firm-specific, I am allowing the firm-fixed effect to capture any elements and control for any persistent firm-level differences, which causes the result to lose its statistical significance and not best represent my study.[7] For this reason, I am less concerned that the coefficient signs and statistical significance for the firm-fixed model does not align with the industry-fixed model.

3) *Robustness Check*

Table 6 represents regression results and controls for firm-fixed effects; Table 7 shows regression results that control for industry-fixed effects. Both results correct for survivorship bias and have a balanced panel data. The final sample for both regressions has 1,663 firms and 14,084 firm-year observations from 1992 to 2013, with no missing data. The drop of 798 firms in the sample size from year t to year t_{+5} can be explained by changes in executive positions, primarily by CEOs leaving firms after year $t_{+k\ (k=1-5)}$. Therefore, I am restricting my sample to a selective subset of tenured-CEOs. I define tenured-CEOs as people who stay with the firm for five-years.[8]

When controlling for industry-fixed effects, the results show that the interactive variable of *vega* and R&D, which measures a manager's incentive for taking on R&D

---

[7] I follow the earnings function established my Lev and Sougiannis (1996), which only includes a set of independent variables such as tangible and intangible assets. Therefore, in my model, I am aware that I did not include control variables that might affect both the dependent and independent variables. Therefore, it is possible that the firm-fixed effects are controlling for any persistent firm-level difference, which lowers the overall significance of my model. I can use instrumental variables and two-stage least squares regression to correct for endogeneity bias. However, since my independent variables are all lagged by one-year, whereas my dependent variable is set at $t_{+k\ (k=0)}$, I am less concerned about the simultaneity bias in my study.

[8] Equilar Inc. (2018) published a study that shows five-year is an average tenure for CEOs at S&P 500 companies.

projects, is positively associated with future earnings for all year $t_{+k\ (k = 0 - 5)}$. This association is statistically significant at the 1% level, which suggests that managers accept R&D projects to raise firm risk, and these investments are realized in future earnings. That is to say, a manager's motivation to increase his wealth by assuming risk in R&D projects, positively impacts the firm's earnings.

However, under firm-fixed effects, this relationship is only statistically significant at year t_{+3}. This finding implies that tenured-managers take on R&D projects that might increase their wealth but not the firm's future earnings. Put differently, these tenured-CEOs are more incentivized to accept R&D projects to increase firm risk — thereby raising their portfolio wealth — rather than the purpose of generating long-term value to the firm. Also, the negative sign of $\text{Vega}_{i,t-1}$ under firm-fixed effects specification indicates that the sole effect of a manger's decision to raise firm risk to augment one's personal wealth, leads to a fall in future earnings. In other words, their actions to increase firm risk, other than investing in R&D, such as taking more leverage and investing in other risky projects, negatively impact firm's earnings. This finding is statistically significant at year $t_{+k\ (k = 2 - 5)}$, which proposes that this effect is more prevalent and significant at a longer-time horizon. The difference in statistical significance for firm and industry-fixed effects arises because the interactive term of *vega* and R&D is less variant under the firm-fixed effect than it is for the industry-fixed effect. Therefore, the firm-fixed effect weakens the explanatory power of $\text{Vega}_{i,t-1}\times\text{R\&D}_{i,t-1}$ on future earnings.

To understand what might have possibly caused the significance to fall when the data has a balanced panel of CEOs, who are in their executive roles consecutively for 5-years, I run a regression on the sample of CEOs who only survived during their first-year in term. If I find a positive and statistical significance of $\text{Vega}_{i,t-1}\times\text{R\&D}_{i,t-1}$ on future earnings, I can conclude that it is this subset of CEOs who did not survive in year t_{+5} that drives the statistical insignificance in a balanced panel data. However, as presented in Appendix 2, I find that there is no statistical significance between managerial incentive for risk taking in R&D and future earnings. This result implies that the managerial incentive for this selective group of CEOs, who stayed with the firm for only one-year, does not affect firm earnings when they assume risk in R&D projects. Therefore, it is the combined effect of both CEOs who did and did not survive at year t_{+5} that drives the loss in statistical significance in a balanced sample. That is to say, by having a balanced panel data, I am restricting my sample to a selective group of tenured-CEOs and leaving out a particular group of CEOs who stayed with the firm for only one year. Moreover, I narrow my sample to CEOs who maintain their executive positions for five-years, which is a reasonable, yet arbitrary number. Therefore, for this empirical context, I am cautious not to conclude that using a restrictive balanced panel infers better significance of the association between managerial incentive on R&D projects and its realization into a firm's future earnings than a non-balanced panel.

VI. Conclusion

In this paper, I address two research questions. First, I test if managerial incentive for risk-taking increases a firm's R&D expenditure. I derive *vega* to measure managerial incentive, and *vega* is a dollar change in ESO for a 0.01 change in stock-return volatility. I find this relationship to be positive and statistically significant at both 5% and 1% levels, when I control for either firm or industry-fixed effects. This result suggests that CEOs who get compensated with stock options assume the risk of R&D investments because they expect this investment decision will increase stock-return volatility, hence, boosting their option portfolio wealth.

With this finding, I do a second study, which assesses if managerial incentive for accepting R&D projects translates to an increase in future earnings. Earnings is a function of tangible and intangible assets (Lev and Sougiannis 1996; Hanlon et al. 2003). Lev and Sougiannis (1996) find that R&D expenditures boost subsequent earnings because they are value-enhancing investments. Hanlon et al. (2003) expand this literature by predicting intangible assets with Black-Scholes ESO value in dollar terms. Since I establish that managerial incentive for risk-taking increases firm's R&D from my first study, I include *vega* into the earnings function, factoring in managerial incentive for assuming risks. I find that as CEOs are more incentivized to increase firm risk by taking on R&D projects, subsequent earnings increase. In other words, a CEO's motivation to raise his stock option portfolio value by taking on R&D projects leads to an increase in the firm's future operating income. This suggests that R&D is a value-enhancing investment to companies. This outcome is statistically significant for all years $t_{+k\ (k = 0\text{-}5)}$, when controlled for industry-fixed effects.

However, for firm-fixed effects, the significance disappears at t_{+4} and $t_{+5.}$ In other words, the realization of R&D investment to future earnings is not prevalent at a longer time horizon when R&D decisions are made by incentivized managers. I re-run this model using a balanced panel, restricting my data to tenured-CEOs for robustness check. Tenured-CEOs are people who stayed with the firm as CEOs for five years. I find loss in statistical significance in all years except $t_{+3,}$ when controlled for firm-fixed effects. This finding proposes that the R&D projects accepted by tenured-managers boost only the firm's risk, not future earnings. That is to say, their choice in R&D projects only increase their wealth and not their firm's wealth.

Throughout my study, I control for either firm or industry-fixed effects. For my first research question, I discover that my results are statistically significant under both conditions. However, for my second study, in which I test the ability of managerial incentive to realize R&D into future earnings, I find the firm-fixed effect model to have less explanatory power than that of an industry-fixed effect model. This is because the cross-term variable of *vega* and R&D is less-variant over time. In other words, the firm-fixed effect weakens the explanatory power.

There are possible areas for future research within this topic. First, depending on manager portfolio diversification, their incentive to increase stock-return volatility might change. In other words, CEOs whose portfolio is heavily ESO-based would react more strongly to changes in stock-return volatility than those whose is not. Therefore, examining how managerial incentive for R&D investment differ when accounting for this aspect could be one area for further research. Also, testing how managerial incentive differs by industry or by size of a firm is another area for future research. Chan et al. (1990) find that technology firms view R&D as long-term value-enhancing investment.

For this reason, CEOs in technology might behave differently to R&D, and their ability to translate R&D to future earnings might vary by industries. Therefore, for future research, I can conduct the same study for each industry and examine which has the highest and strongest managerial incentive for R&D and its realization on future earnings. I can also do this study by firm, categorizing the sample by market capitalization.

Table 1: Summary statistics of executive compensation and firm characteristics

	Mean	Standard Deviation	25th Percentile	50th Percentile	75th Percentile
CEO characteristics					
Vega ($000s)	119	198	13	45	130
Delta ($000s)	576	1227	75	194	526
Firm characteristics					
R&D	0.04	0.08	0.00	0.01	0.05
CAPEX	0.05	0.06	0.02	0.04	0.07
Size	1.99	0.24	1.85	2.00	2.15
Leverage	0.23	0.21	0.06	0.21	0.34
Tobin's Q	1.59	1.70	0.75	1.20	1.92
Sales Growth (%)	0.13	0.76	-0.01	0.07	0.18
Free Cash Flow Level	0.08	0.13	0.04	0.09	0.13

Table 2: Relationship between R&D and Vega

VARIABLES	(1) R&D	(2) R&D
Vega ($mm)	0.00570**	0.0235***
	(2.276)	(6.084)
Delta ($mm)	-0.000713	-0.00257***
	(-1.597)	(-3.325)
CAPEX	0.00527***	-0.291***
	(3.403)	(-11.07)
Size	-0.0359	-0.00276***
	(-1.415)	(-3.456)
Leverage	-0.00719***	-0.0417***
	(-4.516)	(-4.552)
Tobin's Q	-0.0201***	0.0166***
	(-3.290)	(6.050)
Sales growth	-0.000433	0.00287
	(-0.516)	(1.418)
Free Cash Flow Level	-0.144***	-0.294***
	(-4.583)	(-8.791)
Constant	0.101***	0.0862**
	(10.74)	(2.528)
Time fixed effects	YES	YES
Firm fixed effects	YES	NO
2-digit SIC Controls	NO	YES
Observations	22,029	22,029
Number of firms	2,276	
R-squared	0.156	0.405

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Correlation Matrix

	OI_{it}	$Vega_{i,t-1} \times R\&D_{i,t-1}$	$Vega_{i,t-1}$	$R\&D_{i,t-1}$	$TA_{i,t-1}$
OI_{it}	1				
$Vega_{i,t-1} \times R\&D_{i,t-1}$	0.0123	1			
$Vega_{i,t-1}$	0.116^{***}	0.478^{***}	1		
$R\&D_{i,t-1}$	-0.344^{***}	0.384^{***}	-0.0215^{***}	1	
$TA_{i,t-1}$	0.0189^{**}	-0.204^{***}	-0.0802^{***}	-0.332^{***}	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Relationship between managerial incentive for R&D investment and future earnings, controlled for firm-fixed effects

VARIABLES	(1) $OI_{i,t}$	(2) $OI_{i,t+1}$	(3) OI_{it+2}	(4) $OI_{i,t+3}$	(5) $OI_{i,t+4}$	(6) $OI_{i,t+5}$
$Vega_{i,t-1}$×$R\&D_{i,t-1}$	0.549***	0.462**	0.494**	0.569**	0.289	0.220
	(2.818)	(2.167)	(2.172)	(2.451)	(1.103)	(0.840)
$Vega_{i,t-1}$	-0.0107	-0.0181**	-0.0223***	-0.0312***	-0.0335***	-0.0367***
	(-1.542)	(-2.541)	(-2.883)	(-3.761)	(-3.557)	(-3.609)
$R\&D_{i,t-1}$	-0.197**	-0.0519	-0.0600	-0.163**	-0.0540	-0.0272
	(-2.359)	(-0.637)	(-0.911)	(-2.320)	(-0.814)	(-0.173)
$TA_{i,t-1}$	-0.0354**	-0.0156	-0.00393	0.00192	-0.00617	-0.00931
	(-2.506)	(-0.955)	(-0.238)	(0.116)	(-0.317)	(-0.533)
Constant	0.163***	0.139***	0.125***	0.110***	0.0932***	0.0842**
	(9.119)	(5.980)	(5.756)	(3.907)	(3.646)	(2.498)
Time fixed effect	YES	YES	YES	YES	YES	YES
Firm-fixed effect	YES	YES	YES	YES	YES	YES
Observations	24,625	22,164	19,876	17,780	15,854	14,084
R-squared	0.030	0.020	0.016	0.017	0.013	0.011
Number of firms	2,461	2,289	2,097	1,926	1,770	1,663

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Relationship between managerial incentive for R&D investment and future earnings, controlled for industry-fixed effects

VARIABLES	(1) $OI_{i,t}$	(2) $OI_{i,t+1}$	(3) OI_{it+2}	(4) $OI_{i,t+3}$	(5) $OI_{i,t+4}$	(6) $OI_{i,t+5}$
$Vega_{i,t-1} \times R\&D_{i,t-1}$	1.355***	1.380***	1.476***	1.613***	1.561***	1.519***
	(7.944)	(8.055)	(8.243)	(7.598)	(6.694)	(6.138)
$Vega_{i,t-1}$	0.0266***	0.0256***	0.0218***	0.0156*	0.0145	0.0138
	(3.448)	(3.256)	(2.761)	(1.848)	(1.593)	(1.413)
$R\&D_{i,t-1}$	-0.783***	-0.747***	-0.739***	-0.757***	-0.708***	-0.674***
	(-15.02)	(-13.12)	(-11.94)	(-9.722)	(-8.719)	(-7.645)
$TA_{i,t-1}$	-0.0431***	-0.0358***	-0.0347***	-0.0356***	-0.0313**	-0.0298**
	(-4.168)	(-3.372)	(-3.314)	(-3.400)	(-2.517)	(-2.240)
Constant	0.0619*	0.0551	0.0447	0.0834	0.0717	0.0597
	(1.754)	(1.370)	(1.022)	(1.560)	(1.326)	(1.012)
Time fixed effect	YES	YES	YES	YES	YES	YES
2-digit SIC effect	YES	YES	YES	YES	YES	YES
Observations	24,625	22,164	19,876	17,780	15,854	14,084
R-squared	0.181	0.164	0.157	0.158	0.141	0.131

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Relationship between managerial incentive for R&D investment and future earnings, controlled for firm-fixed effects *(N = 14,084)*

VARIABLES	(1) $OI_{i,t}$	(2) $OI_{i,t+1}$	(3) OI_{it+2}	(4) $OI_{i,t+3}$	(5) $OI_{i,t+4}$	(6) $OI_{i,t+5}$
$Vega_{i,t-1}$×$R\&D_{i,t-1}$	0.161	0.0355	0.262	0.498**	0.229	0.220
	(0.998)	(0.189)	(1.251)	(2.125)	(0.972)	(0.841)
$Vega_{i,t-1}$	-0.00951	-0.0113	-0.0192**	-0.0348***	-0.0342***	-0.0367***
	(-1.175)	(-1.438)	(-2.374)	(-3.940)	(-3.694)	(-3.610)
$R\&D_{i,t-1}$	-0.0974	0.138*	0.0853	-0.128	0.0148	-0.0272
	(-1.142)	(1.830)	(1.390)	(-1.537)	(0.278)	(-0.173)
$TA_{i,t-1}$	-0.0153	-0.00736	-0.00164	-0.00664	-0.0163	-0.00939
	(-0.775)	(-0.345)	(-0.0786)	(-0.353)	(-0.727)	(-0.537)
Constant	0.151***	0.133***	0.121***	0.114***	0.0949***	0.0843**
	(6.952)	(5.242)	(5.513)	(4.145)	(3.749)	(2.499)
Time fixed effect	YES	YES	YES	YES	YES	YES
Firm-fixed effect	YES	YES	YES	YES	YES	YES
Observations	14,084	14,084	14,084	14,084	14,084	14,084
R-squared	0.027	0.024	0.019	0.017	0.013	0.011
Number of firms	1,663	1,663	1,663	1,663	1,663	1,663

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Relationship between managerial incentive for R&D investment and future earnings, controlled for industry-fixed effects *(N = 14,084)*

VARIABLES	(1) $OI_{i,t}$	(2) $OI_{i,t+1}$	(3) OI_{it+2}	(4) $OI_{i,t+3}$	(5) $OI_{i,t+4}$	(6) $OI_{i,t+5}$
$Vega_{i,t-1} \times R\&D_{i,t-1}$	1.495***	1.380***	1.521***	1.667***	1.525***	1.519***
	(7.079)	(6.753)	(7.480)	(6.960)	(6.155)	(6.137)
$Vega_{i,t-1}$	0.0162*	0.0201**	0.0154*	0.00901	0.0122	0.0139
	(1.728)	(2.161)	(1.805)	(0.989)	(1.293)	(1.415)
$R\&D_{i,t-1}$	-0.758***	-0.678***	-0.693***	-0.739***	-0.686***	-0.674***
	(-10.39)	(-9.975)	(-11.27)	(-9.078)	(-8.068)	(-7.645)
$TA_{i,t-1}$	-0.0343**	-0.0254**	-0.0263**	-0.0357***	-0.0323**	-0.0298**
	(-2.501)	(-1.987)	(-2.361)	(-3.231)	(-2.498)	(-2.240)
Constant	0.155***	0.0768**	0.0714**	0.0685**	0.0538	0.0388
	(4.225)	(2.402)	(2.095)	(2.063)	(1.179)	(0.750)
Time fixed effect	YES	YES	YES	YES	YES	YES
2-digit SIC effect	YES	YES	YES	YES	YES	YES
Observations	14,084	14,084	14,084	14,084	14,084	14,084
R-squared	0.174	0.150	0.154	0.162	0.143	0.131

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 1: Relationship between R&D and Vega, adjusted for price-level in 2018

VARIABLES	(1) R&D	(2) R&D
Vega ($mm)	0.00592***	0.0192***
	(2.634)	(5.762)
Delta ($mm)	-0.000537	-0.00193***
	(-1.437)	(-3.188)
CAPEX	0.00533***	-0.299***
	(3.217)	(-10.91)
Size	-0.0429	-0.00280***
	(-1.570)	(-3.355)
Leverage	-0.00766***	-0.0420***
	(-4.473)	(-4.331)
Tobin's Q	-0.0233***	0.0162***
	(-3.402)	(5.726)
Sales growth	-0.000407	0.00271
	(-0.510)	(1.436)
Free Cash Flow Level	-0.152***	-0.295***
	(-4.600)	(-8.384)
Constant	0.101***	0.0862**
	(10.74)	(2.528)
Time fixed effects	YES	YES
Firm fixed effects	YES	NO
2-digit SIC Controls	NO	YES
Observations	22,029	22,029
Number of firms	2,276	
R-squared	0.156	0.405

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix 2: Regression for CEOs that left the firm after $t_{+k\ (k=0)}$

VARIABLES	(1) $OI_{i,t}$
$Vega_{i,t-1} \times R\&D_{i,t-1}$	0.0151
	(0.0605)
$Vega_{i,t-1}$	-0.00477
	(-0.503)
$R\&D_{i,t-1}$	0.137
	(0.937)
$TA_{i,t-1}$	-0.113***
	(-3.933)
Constant	0.246***
	(10.72)
Time fixed effect	YES
CEO fixed effect	YES
Observations	10,542
Number of firms	2,461
R-squared	0.026

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

References

Ali, Ashiq and Weining Zhang, 2015, CEO tenure and earnings management, *Journal of Accounting and Economics* 59(1): 60-79.

Bergstresser, Daniel and Thomas Philippon, 2006, CEO incentives and earnings management, *Journal of Financial Economics* 80(3): 511-529.

Black, Fischer and Scholes Myron, 1973, The pricing of options and corporate liabilities, *Journal of Political Economy* 81(3): 637-654.

Bushee, Brian J., 1998, The influence of institutional investors on myopic R&D investment behavior, *American Accounting Associatio*n 73(3): 305-333.

Chan, Su Han, John D. Martin, and John W. Kensinger, 1990, Corporate research and development expenditures and share value, *Journal of Financial Economics* 26(2): 255-276.

Cohen, Randolph B., Brian J. Hall, and Luis M. Viceira, 2000, Do executive stock options encourage risk-taking?, Harvard Business School.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* 79(2): 431-468.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, 2013, Calculation of Compensation Incentives and Firm-Related Wealth Using Execucomp: Data, Program, and Explanation. Available at SSRN.

Core, John and Wayne Guay, 2002, Estimating the value of executive stock option portfolios and their sensitivities to price and volatility, *Journal of Accounting Research* 40(3): 613-630.

Dechow, Patricia M., and Richard G. Sloan, 1991, Executive incentives and the horizon problem: an empirical investigation, *Journal of Accounting and Economics* 14(1): 51-89.

Equilar.com. (2018). CEO tenure drops to just five years. Available at: https://www.equilar.com/blogs/351-ceo-tenure-drops-to-five-years.html.

Guay, Wayne, 1999, The sensitivity of CEO wealth to equity risk: an analysis of the magnitude and determinants, *Journal of Financial Economics* 53(1): 43-71.

Hanlon, Michelle, Shivaram Rajgopal and Terry Shevlin, 2003, Are executive stock options associated with future earnings?, *Journal of Accounting and Economics* 36(1): 3-43.

Hirschey, Mark and Jerry J. Weygandt, 1985, Amortization policy for advertising and research and development expenditures, *Journal of Accounting Research* 23(1): 326-335.

Jensen, Michael and William Meckling, 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure, *The Journal of Financial Economics* 3(4): 305-360.

Johnson, Lewis D., and Bohumir Pazderka, 1993, Firm value and investment in R&D, *Managerial and Decision Economics* 14(1): 15-24.

Knopf, John D., Jouahn Nam, and John H. Thornton Jr., 2002, The volatility and price sensitivities of managerial stock option portfolios and corporate hedging, *The Journal of Finance* 57(2): 801-813.

Lev Baruch and Theodore Sougiannis, 1996, The capitalization, amortization, and value-relevance of R&D, *Journal of Accounting and Economics* 21(1): 107-138.

Merton. Robert C., 1973, The theory of rational option pricing, Bell Journal of Economics and Managemnet Science 4(1): 141-183.

Porter, Michael E., 1992, Changing the way America invests in industry, *Journal of Applied Corporate Finance* 5(2): 4-16.

Rajgopal, Shivaram and Terry Shelvin, 2002, Empirical evidence on the relation between stock option compensation and risk taking, *Journal of Accounting and Economics* 33(2): 145-171.

Sougiannis, Theodore, 1994, The accounting based valuation of corporate R&D, *The Accounting Review* 69(1): 44-68.