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# CEO risk incentives and firm performance following R&D increases

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ABSTRACT

In this study we analyze how CEO risk incentives affect the efficiency of research and development (R&D) investments. We examine a sample of 843 cases in which firms increase their R&D investments by an economically significant amount over the period of 1995–2006. We find that firms with higher sensitivity of CEO compensation portfolio value to stock volatility (vega) are more likely to have large increases in R&D investments. More importantly, we find that high-vega firms experience lower abnormal stock returns and lower operating performance compared to their low-vega counterparts following the R&D increases. Our main results hold in a variety of robustness tests. The results are consistent with the conjecture that high-vega compensation portfolios may induce managers to overinvest in inefficient R&D projects and therefore hurt firm performance.



## 1. Introduction

Equity-based compensation has the potential to align the incentives of managers with those of shareholders. Prior literature (e.g., Smith and Stulz, 1985; Guay, 1999; Knopf et al., 2002) proposed that the use of options and in particular the resulting sensitivity of managerial wealth to stock price volatility can overcome managerial risk aversion and encourage risk-taking behavior. Perhaps as a reflection of this perceived benefit, the use of stocks and options as compensation has dramatically increased over the past few decades (Yermack, 1995; Bergstresser and Philippon, 2006). Along with this development has come a concern that the high sensitivity of managerial wealth to stock price volatility may induce managers to undertake risky investments without adequate consideration to profitability.[1]

Our study examines the validity of this concern in the context of R&D investment. We investigate whether the sensitivity of CEO compensation portfolio value to stock volatility (vega) affects the propensity for, and especially the *efficiency* of, R&D investment. If vega indeed induces suboptimal managerial risk-taking behavior, one would expect to find that high compensation vega increases R&D investment but may decrease R&D efficiency.

We focus on R&D investments for several reasons. First, as we have moved more and more toward a knowledge-based and innovation-driven economy, R&D has assumed a greater importance in corporate investments and the efficiency of R&D projects has more significant influence on firms' future performance. Second, there is a widespread understanding that R&D investments are highly risky in nature and thus undertaking R&D is an effective means for managers to increase firm risks (Coles et al., 2006). Most importantly, R&D investment is unique in that it is tangible in cost but intangible in benefits. Managers with high-vega compensation portfolios would thus have stronger incentives to *over*-invest in R&D projects, instead of increasing capital investment, in order to pursue their own self-interests for the following reasons.

First, prior studies have shown that investors have difficulty in assessing the quality of R&D investment due to its intangible

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[1] Guay (1999) finds that stock options, as opposed to common stockholdings, significantly increase the sensitivity of CEOs' wealth to equity risk. It suggests that the vega of a compensation portfolio is mainly determined by the option holdings in the CEO compensation portfolio. Option-based compensation that has been dramatically increased in the past few decades might result in excessively high vega in some firms.

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nature (see, e.g., Kothari et al., 2002; Gu and Wang, 2005).[2] Increases in R&D investment tend to increase the divergence of opinion among investors, and thus, result in greater stock return volatility. Therefore, managers with high-vega compensation portfolios will likely have stronger incentives to increase R&D investment (as opposed to increasing capital investment), since the value of their compensation portfolio is highly sensitive to stock volatility. Second, the intangible nature of R&D investment tends to obfuscate investors in the short term (see, e.g. Daniel and Titman, 2006).[3] Investments in inefficient R&D projects induced by high compensation vega are thereby more likely to be carried out than are inefficient capital investments because shareholders are likely unable to distinguish low-quality R&D projects from high-quality ones in a timely manner and effectively detect managerial self-dealing in R&D investment decisions. Taken together, due to its unique nature, R&D investment provides fertile ground for us to detect whether high vega induces excessive managerial risk-taking behavior in investment decisions at the expense of profitability.

Although equity-based compensation has several characteristics such as delta (the sensitivity of CEO compensation portfolio value to stock price), our focus here is on vega which is defined as the change in the value of a compensation portfolio for a 1% change in stock return standard deviation. Prior studies show that a manager's exposure to vega may induce her or him to adopt corporate strategies that increase stock price volatility. For example, Coles et al. (2006) show that higher vega induces greater R&D investment. While this result is suggestive in the sense that vega increases risk-taking—recall that R&D is perceived as risky—it does not fully address the concern that the risk may be pursued at the expense of profitability.[4] We conjecture that, due to the intangible nature of R&D benefits, managers with high-vega compensation portfolios would have stronger incentives to overinvest in inefficient R&D projects in order to pursue their own self-interests. Our study more directly addresses this concern by focusing on the efficiency of R&D investments. Thus our study complements this previous work.

Several previous studies find that increased R&D investments enhance shareholder wealth and operating performance. For example, Eberhart et al. (2004) show that increases in R&D expenditure are associated with subsequent positive abnormal stock returns and better operating performance. They interpret their findings as evidence that R&D increases are beneficial investments, and also that the market is slow to recognize the extent of the R&D investment benefit. However, this finding is not a foregone conclusion. We hypothesize that if the vega of a CEO compensation portfolio has an influence on the efficiency of R&D investments, vega can contribute to, and help explain, the cross-sectional variation in firm performance following R&D increases. Specifically, firms with excessively high vega would be more likely to overinvest in non-value-added, or even value-destroying, R&D projects; therefore, they would experience comparatively weaker stock performance and operating performance after the R&D investment increases.[5] Our study provides a more nuanced look at the relation between R&D and firm performance.

We study 843 instances in which firms increased their R&D expenditures by an economically significant amount. Our study sample spans the period from 1995 to 2006. We find that firms with higher vega have significantly (statistically and economically) weaker long-term abnormal stock returns following their R&D increases. On average, high-vega firms underperform their low-vega counterparts by more than 0.78% per month in stock returns. We also show that the operating performance of high-vega firms following the R&D increases is significantly lower than the operating performance of low-vega firms. These results validate the concern that the high vega of a CEO compensation portfolio may induce suboptimal R&D investment behavior. The results of our subsample tests also indicate that our main findings hold in both high-tech (high-growth) and non-high-tech (low-growth) subsamples.

Our study's main contribution is to the existing body of executive compensation literature. We contribute to the understanding of how equity-based compensation affects shareholder wealth and operating performance. Prior literature presents mixed results concerning this relationship with some studies indicating the lack of a relationship and others showing either a positive or a negative effect. As an example of a study indicating no effect, Palia (2001) finds no significant relation between pay-for-performance sensitivity (PPS) and firm value using a sample constructed over the period from 1981 to 1993. Other studies show either positive or negative effects. Among studies showing a positive effect, Kato et al. (2005) examine the adoption of stock-option compensation by Japanese firms following a regulatory change in 1997 and report a 2% return around the announcement date of the adoption plan as well as a significant improvement in operating performance following the adoption. Among studies showing a negative effect, Brick et al. (2012) show that high delta and high vega are associated with lower future stock returns. We contribute further to the topic by showing that firms in the high-vega group experience significantly lower abnormal stock returns and weaker operating performance following R&D investment increases. In this way, we identify a specific mechanism through which equity-based compensation can affect corporate investment efficiency and thereby influence shareholder wealth.

Our study also adds evidence to the literature on the dark side of managerial equity-based compensation. Bergstresser and Philippon (2006) and others find evidence that managers whose compensation is more directly tied to share prices are more likely to manipulate earnings. Burns and Kedia (2008) and others show that managerial equity-based compensation is positively related to the propensity to misreport and managers do realize the potential

[2] For example, Kothari et al. (2002) find that R&D investments generate future benefits that are far more uncertain than the benefits from capital investments in property, plant and equipment. Lev and Sougiannis (1996) and several other studies also suggest that investors sometimes do not fully recognize the intangible benefits of R&D projects and understand the efficiency of innovation activities. Gu and Wang (2005) and others find that analysts' forecast errors are positively associated with R&D intensity, clearly suggesting that even sophisticated market participants such as analysts do not fully understand the relation between R&D and subsequent firm profitability.

[3] Eberhart et al. (2004) argue that the potential benefit of an R&D increase reflects intangible information about future cash flows. According to Daniel and Titman (2006), investors cannot fully digest intangible information; thus, they may be slow to recognize the extent of the benefit underlying different R&D investments.

[4] Despite the relevance of this concern, the evidence on whether managerial risk incentives lead to excessive risk taking is scarce. This is partially because of the difficulty of establishing how much risk taken by managers is too much. The only exception that we are aware of is Dong et al. (2010). They find that the probability of debt offering increases with CEO compensation vega even in an over-levered subsample, suggesting that high vega may induce managers to pursue suboptimal capital structure by overleveraging their companies so as to increase the value of their compensation portfolio.

[5] Due to the intangible nature of R&D investment benefits, investors have great difficulty in fully digesting intangible information (Daniel and Titman, 2006), and thus, have great difficulty in differentiating inefficient R&D investments from value-added R&D investments. Investors tend to be slow to recognize the intangible benefits of various R&Ds and might respond similarly to R&Ds across different firms, although some of the R&Ds might be inefficient R&Ds induced by excessively high vega. In the long run, when the benefits of inefficient R&D investments in high-vega firms fall short of the initial assessment of investors, stock returns along with operating performance of the high-vega firms should underperform their low-vega counterparts.