EXECUTIVE COMPENSATION PORTFOLIO SENSITIVITIES AND THE COST OF EQUITY CAPITAL

Abstract

Executive compensation portfolio sensitivities to change in stock price (*deltas*) and stock return volatility (*vegas*) influence managerial risk-taking decisions. Large *deltas* discourage risk-taking while large *vegas* encourage risk-taking. In this paper, we examine the relation between executive compensation portfolio *delta*s and *vegas* and the implied cost of equity capital. We show that managerial risk incentives, as captured by executive compensation portfolio *deltas* and *vegas*, determine the rate of return expected by shareholders. Higher *deltas* (*vegas*) are associated with a lower (higher) implied cost of equity capital. In a change-in-variable specification, we find that an increase (decrease) in *delta* (*vega*) results in a decrease (increase) in the implied cost of equity capital. We also show that higher *deltas* are associated with lower external equity financing costs as *deltas* and the underpricing of seasoned equity offerings are inversely related. Taken together, our findings demonstrate that shareholders understand managerial risk incentives embedded in executive compensation and price these risks into the cost of equity capital accordingly.

JEL: G30; G322

Keywords: Executive compensation; *Deltas*; *Vegas*; Implied cost of equity capital; SEO underpricing.

EXECUTIVE COMPENSATION PORTFOLIO SENSITIVITIES AND THE COST OF EQUITY CAPITAL

1. Introduction

In response to the significant increase in the use of stocks and options in executive compensation over the past few decades, a large body of literature has devoted considerable attention to understanding the role of executive compensation in corporate governance and firm performance. [1] Furthermore, recent studies have also examined how executive compensation affects managerial behavior, risk-taking decisions and their impacts on the firm's overall risk. There is mounting evidence that executive compensation portfolio *deltas*, the sensitivity of the stock and option compensation portfolio value to company stock prices, lower managerial risk preferences (Lambert *et al*., 1991; Carpenter, 2000; Knopf *et al*., 2002) while executive compensation portfolio *vegas*, the sensitivity of the option compensation portfolio to company stock return volatility, increase managerial risk preferences (Knopf *et al*., 2002; Coles *et al*., 2006; Brockman *et al*., 2010; Armstrong and Vashishtha, 2011).

Prior research has investigated the effects of *delta*s and *vegas* on managerial risk preferences to firm choices of risky investment and financing policies (Coles *et al*., 2006), firms' hedging activities (Rogers, 2002; Knopf *et al*., 2002), firms' risk-taking in merger and acquisition activities (Hagendorff and Vallascas, 2011), firm's choices of financial reporting (Cheng and Warfield, 2005; Grant *et al*., 2009; Chava and Purnanandam, 2010), firm's short-term debt (Brockman *et al*., 2010), and firm's cash holdings (Liu and Mauer, 2011). Given that *deltas* and *vegas* determine several risk-taking aspects of a firm, this study aims to investigate whether shareholders price managerial risk incentives. Specifically, we examine

[1] Over the period 1993-2003, executive pay increased sharply with the aggregate compensation to the top five executives of each of the S&P 1500 firms doubling from 5 percent to 10 percent of the aggregate earnings of those firms (Bebchuk and Grinstein, 2005).

the relation between executive compensation portfolio *delta*s and *vegas* and the *ex-ante* measure of cost of equity capital, namely the implied cost of equity capital. We focus on the cost of equity capital because of its paramount importance in a firm's financing and operating decisions. Furthermore, while several prior studies have shown that management aims to reduce the cost of equity capital by adopting voluntary disclosure (Diamond and Verrecchia, 1991; Botosan, 1997; Leuz and Verrecchia, 2000; Botosan and Plumlee, 2002; Graham *et al*., 2005; Dhaliwal *et al*., 2010) or smoothing earnings (Francis *et al*., 2004; Verdi, 2006), no study has examined the relation between managerial risk incentives embedded in executive compensation and shareholders' perception of these risk incentives.

We employ a sample of 11,041 firm-year observations from the S&P1500 over the period 1992-2009 and construct CEO compensation portfolio sensitivities as in Core and Guay (2002) to study the association between CEO risk incentives and the implied cost of equity capital. In undertaking this analysis, we employ four *ex-ante* measures of the cost of equity capital, deduced from the valuation models of Claus and Thomas (2001), Gebhardt *et al*. (2001), Gode and Mohanram (2003), and Easton (2004). Following Dhaliwal *et al*. (2005, 2006), Hail and Leuz (2006), and Dhaliwal *et al*. (2010), we also consider an average-based measure of the implied cost of equity capital by taking the equally weighted average of the four individual implied cost of equity capital estimates. Our basic hypothesis is that when a CEO has an incentive to increase the firm's overall risk by adopting riskier corporate policies and investment projects, shareholders demand compensation for bearing this excessive risk by increasing the cost of equity capital.[2] The reverse happens when the CEO has an incentive to reduce the firm's overall risk. In testing these hypotheses, we compute CEO *deltas* and

[2] The adoption of riskier corporate policies and investment projects can increase a firm's systematic risk and idiosyncratic risk. While we do not aim to disentangle the effects of risk incentives on systematic risk and idiosyncratic risk, our basic assumption is that the cost of equity capital is an increasing function of the firm's overall risk. The extant empirical literature still has not reached consensus on whether idiosyncratic risk is priced (Botosan, 1997; Botosan and Plumlee, 2002; Botosan *et al*., 2004) or not priced (Cohen, 2004; Chen *et al*., 2004; Nikolaev and van Lent, 2005; Hughes *et al*., 2007).

vegas as proxies for risk-taking incentives based on the CEO's personal holdings of the firm's stocks and options. CEOs with higher *deltas* are likely to decrease the firm's overall risk and thus lower the cost of equity capital because they have a large exposure to the firm's total risk which is not diversifiable (Fama, 1980; Stulz, 1984; Smith and Stulz, 1985). In addition, higher *deltas* can reduce the cost of equity capital through the outcome of the incentive alignment effect. Higher *deltas* motivate CEOs to work towards increasing shareholders' wealth, thereby reducing the agency cost between shareholders and managers. CEOs with high *vegas* stand to gain from higher volatility and thus have an incentive to increase the firm's overall risk, which leads to a higher cost of equity capital.

Our empirical findings offer three important new insights. First, we show that firms with higher CEO compensation portfolio *deltas* are associated with a significantly lower implied cost of equity capital while firms with higher CEO compensation portfolio *vegas* are associated with a significantly higher implied cost of equity capital. The lower implied cost of equity capital among high CEO compensation portfolio *delta* firms and the higher implied cost of equity capital among high CEO compensation portfolio *vega* firms are observed consistently across all individual measures of the implied cost of equity capital as well as the average-based measure of the implied cost of equity capital. For the average-based measure of the implied cost of equity capital, the effect of CEO compensation portfolio *deltas* on the cost of equity capital is a reduction of 60 basis points going from the 25^{th} percentile to the 75^{th} percentile of CEO compensation portfolio deltas. The effect of CEO compensation portfolio *vegas* on the average-based measure of the implied cost of equity capital is somewhat smaller with an increase of 16 basis points going from the 25^{th} percentile to the 75^{th} percentile of CEO compensation portfolio *vegas*.

Second, using a change-in-variables regression specification, we show that the annual change in CEO compensation portfolio *delta*s (*vegas*) is negatively (positively) and significantly related to the annual change in all of our implied cost of equity measures. When we consolidate *vega* and *delta* into a ratio representing one overall measure of risk-incentive as in Rogers (2002, 2005) and Grant *et al*. (2009), we find that a higher ratio of *vega* over *delta* (*i.e.*, a high risk incentive) is associated with a significantly higher cost of equity capital. In addition, extending compensation sensitivity measures to reflect *deltas* and *vegas* of the compensation package for the top five executives of a firm, we document that their compensation portfolio *deltas* (*vegas*) are associated with a lower (higher) cost of equity capital. When we decompose *deltas* into stock *deltas* and option *deltas*, we find that both stock *deltas* and option *deltas* exert negative effects on the cost of equity capital with the effect being exceedingly stronger for the latter.

Our empirical findings remain robust when we address endogeneity concerns by including the lagged implied cost of equity capital in the regression analysis, or using *delta* and *vega* measures that exclude the current year compensation, or adopting a two-stage instrumental variable approach to investigate the relation between executive compensation portfolio sensitivities and the cost of equity capital. In our final avenue of inquiry, we examine the relation between managerial risk incentives and the underpricing of seasoned equity offerings (SEOs) which is generally considered a measure of the cost of external equity financing. We find that higher *deltas* are associated with significantly lower underpricing of SEOs but do not find a significant relation between *vegas* and the underpricing of SEOs.

Collectively, our findings are consistent with the proposition that managerial risk incentives, as captured by compensation portfolio sensitivities to stock price and stock return volatility, influence investors' perception of risk, leading to variation in the expected return on equity. We make two significant contributions to the cost of equity capital and executive compensation literature. First, our study is the first to show that shareholders understand and price managerial risk-taking behavior as manifested by the negative (positive) relation between executive compensation portfolio *deltas* (*vegas*) and the implied cost of equity capital. Prior studies have shown that management can take a number of initiatives to reduce the cost of equity capital such as adopting voluntary disclosure, striving for a more transparent information environment, or smoothing earnings (Francis *et al*., 2004; Verdi, 2006). We show that management can also influence shareholders' perception of risk, and thus the cost of equity capital, by conveying their risk appetite as embedded in executive compensation. In addition, a large strand of literature focuses on identifying the cross-sectional determinants of a firm's cost of equity capital (Dhaliwal *et al*., 2005; Dhaliwal *et al*., 2006; Lambert *et al*., 2007; Naiker *et al*., 2011). We make a significant contribution to this literature by establishing that executive risk incentives are important determinants, both statistically and economically.

Second, we contribute to the literature on executive compensation by examining market-based assessments of executive risk incentives. While a growing body of empirical work analyzes the effects of risk incentives on corporate policies, investment choices, and the firm's overall risk (Knopf *et al*., 2002; Rajgopal and Shevlin, 2002; Hanlon *et al*., 2004; Coles *et al*., 2006; Brockman *et al*., 2010; Chava and Purnanandam, 2010), our analysis of the implied cost of equity capital allows us to investigate whether the relation between risk incentives and corporate policies drives market-based assessments of the firm's overall risk. We establish a causal link between managerial risk incentives as embedded in the compensation contract and the implied cost of equity capital, a measure of the risk premium demanded *ex-ante* by shareholders. Our findings therefore have important implications for optimal corporate compensation design and the regulation of executive compensation.

The rest of this study is organized as follows. Section 2 discusses related research and develops testable hypotheses. Section 3 describes the measurement of the main variables and sample selection. Section 4 presents the descriptive statistics and Section 5 presents the empirical results. Section 6 concludes the study.

2. Related Literature and Testable Hypothesis

The separation of ownership and control in publicly held corporations has long been recognized as a major source of conflict between shareholders and management (Berle and Means, 1932; Jensen and Meckling, 1976; Demsetz, 1983) and an extensive literature has focused on the shareholder-value ramifications of this agency cost. While shareholders are often considered risk-neutral with regard to firm specific risk as they can hold well-diversified investment portfolios, corporate managers whose human capital and money capital are invested in the firm hold undiversified risk. As a consequence, managers may have an incentive to reduce firm risk more than what may be desirable to generally diversified shareholders (Shavell, 1979; Smith and Stulz, 1985; Stiglitz, 1987; Guay, 1999; Fama and French, 1992; Beatty and Zajac, 1994). Risk-neutral shareholders would like to accept all positive net present value (NPV) projects while risk-averse managers may pass on positive NPV projects that are risky.

Executive compensation packages that align managers' wealth with corporate performance or a firm's stock value have generally been considered a solution to the agency problem (Holmstrom, 1979; Baker *et al*., 1988). In the past few decades, the use of stock options as part of U.S. executive compensation has grown exponentially and beyond what can be explained by changes in firm size, firm performance or industry classification (Bebchuk and Grinstein, 2005).[3] Stock options are an important mechanism to mitigate managerial risk aversion to firm-specific risk because they create a convex relationship

[3] Several studies have shown that grants of stock options represent the largest component of CEO compensation in large publicly listed corporations in the U.S. (Hall and Liebman, 1998; Murphy, 1999).

between pay and performance (Smith and Stulz, 1985; Lambert, 1986; Guay, 1999; Lambert and Larcker, 2004). Specifically, managers who hold company stock options are shielded from the downside risk when the stock price falls below the option strike price but enjoy unlimited gain when the stock price exceeds the option strike price. Consequently, option compensation motivates managers to accept and take more risk.

While the primary use of stock options in executive compensation packages is to align management's wealth with firm performance, recent literature on executive compensation recognizes that the use of stock options can incentivize executives to engage or disengage in risk-taking behavior. Ross (2004) sums up the literature by stating: "*The common folklore that giving options to agents will make them more willing to take risks is false*." Overall, Carpenter (2000), Lambert *et al*. (1991), Knopf *et al*. (2002), and Ross (2004) suggest two opposing effects of stock option portfolio sensitivities on managerial incentives. First, the payoff of an option ties a manager's wealth to the stock price and, as a result, reduces the risk-averse manager's willingness to take risk. This effect increases in option portfolio *deltas*, the relative sensitivity of the option portfolio value to changes in stock price. Second, because of the convex payoff structure of an option, the value of a manager's option portfolio increases in stock return volatility and this gives the manager an incentive to take more risk. This effect increases in option portfolio *vegas*, the relative sensitivity of the option portfolio value to stock return volatility. Collectively, these studies posit that the sensitivities inherent in managers' stock and option portfolios to stock price and stock return volatility can cause managerial risk preference and risk-taking to move in opposite directions.

Several studies have provided empirical evidence that executive compensation portfolio sensitivities are important in assessing managerial incentives and firms' risk-taking activities. Knopf *et al*. (2002) show that managers with high *deltas* conduct more corporate risk hedging activities to reduce firms' exposure to risk while managers with high *vegas* conduct less corporate hedging activities. In a similar vein, Rajgopal and Shevlin (2002) find that firms in the oil and gas industry engage in greater exploration risk and less corporate risk hedging activities when their CEOs possess high *vega* option portfolios. Coles *et al*. (2006) further show that CEOs with high *vega* option portfolios exhibit higher risk-taking behavior through the choice of corporate investment policy and corporate financing policy. These researchers find that CEOs with high *vega* option portfolios tend to use higher financial leverage, larger research and development expenditures and less capital expenditures. Armstrong and Vashishtha (2011) show that *vegas* give CEOs an incentive to increase firm's systematic risk. Other studies such as Bliss and Rosen (2001), Minnick *et al*. (2009), De Young *et al*. (2010), and Hagendorff and Vallascas (2011) document that high *delta* banks engage in less risky banking activities while high *vega* banks engage in riskier types of activities. Grant *et al*. (2009) show that CEO risk-related incentives embedded in compensation contract, as captured by the ratio of CEO *vega* over *delta*, are positively related to income smoothing. They conclude CEO risk-taking behavior is accompanied by financial reporting decisions as manifested by managers employing income smoothing to reduce unintended consequences of risk.[4]

Recent research documents that creditors take into account the effect of executive compensation portfolio sensitivities on management risk-taking behavior. Billett *et al*. (2010) find that bondholders react negatively upon new CEO stock options grant announcements and the negative response is more pronounced with high *vega* stock option grants and milder with high *delta* options grants. Brockman *et al*. (2010) find a negative (positive) relation between CEO compensation portfolio *deltas* (*vegas*) and short-maturity debt. They conclude that firms

---

[4] Grant *et al*. (2009) posit that income smoothing can be used as a mechanism to avoid the undesirable consequences of risk on reported earnings such as potentially large losses, wide fluctuations, and to serve shareholder interests and institutional investors' preferences. Other studies that document a positive relation between CEO risk-taking incentives embedded in compensation contracts and CEO risk-taking behavior include Tufano (1996), Rogers (2002, 2005), Nam *et al*. (2003), Mehran and Rosenberg (2007), Billet *et al*. (2010), Liu and Mauer (2011), and Tchistyi *et al*. (2011).

use short-maturity debt to mitigate the agency cost of debt because short-maturity debt can constrain managerial risk preferences.[5] These studies are generally in line with the theoretical prediction in Barnea *et al*. (1980) that debt-holders discount debt value once they recognize the management' incentive problem.

This study examines the relation between executive risk-related incentives embedded in the compensation contract and the implied cost of equity capital, an *ex-ante* measure of the premium demanded by shareholders. We primarily focus on the risk incentives of CEOs as they are the most influential in a firm's policy choices and risk-taking. The effect of CEO compensation portfolio *deltas* on the cost of equity capital is expected to be negative for two reasons. First, Lambert *et al*. (1991), Carpenter (2000), and Ross (2004) argue that a risk-averse and under-diversified manager has a strong incentive to adopt risk-reducing policy choices if the compensation has high pay-for-performance sensitivity, leading to lower overall risk and expected stock returns for the firm. Second, if high *deltas* motivate managers to work hard or more effectively to increase shareholders' wealth, we would expect a reduction in the agency cost due to the enhanced alignment between managers' and shareholders' interests, leading to a lower cost of equity capital. This discussion leads to our first testable hypothesis, which can be stated as follows.

H_1: The implied cost of equity capital is negatively related to the sensitivity of CEO compensation portfolios to stock price (*deltas*).

Coles *et al*. (2006) demonstrate that CEO compensation with higher *vegas* motivates the CEO to pursue riskier investment and financing policies. This risk-taking behavior is expected to result in higher firm's overall risk and higher expected stock returns. Strobl (2003) theorizes risk-taking incentives as a source of non-diversifiable risk to shareholders and thus shareholders may also demand compensation for bearing this risk in the form of higher cost

[5] Brockman *et al*. (2010) also document that short-maturity debt reduces the influence of *vegas* and *deltas* incentives on corporate bond yields.

of equity capital. Moreover, risk-taking incentives can increase the cost of equity capital by increasing a firm's cash flow volatility which is positively associated with the costs of both debt and equity financing (Bernadette and Schrand, 1999). This discussion leads to our second testable hypothesis, which can be stated as follows.

H_2: The implied cost of equity capital is positively related to the sensitivity of CEO compensation portfolios to stock return volatility (*vegas*).

3. Variable Measurement and Sample Selection

3.1 Dependent Variable: Implied Cost of Equity Capital

To empirically examine the association between the implied cost of equity capital and CEO compensation portfolio sensitivities, we first estimate the cost of equity capital that is implied in current stock prices and analysts' earnings forecasts. More specifically, we infer estimates of the implied cost of equity using the methods of Claus and Thomas (2001), Gebhardt *et al*. (2001), Gode and Mohanram (2003) and Easton (2004). The extant literature adopts these methods to *ex-ante* infer an estimate of the implied cost of equity using the residual income and growth valuation models developed by Ohlson (1995), Feltham and Ohlson (1995), and Ohlson and Juettner-Nauroth (2005). We refer to the estimates based on these methods as R_{CT}, R_{GLS}, R_{GM}, and R_{EAST}, respectively.

Since there is little consensus in the extant literature on which model yields the best performance and there is no guidance on how these models should be evaluated (see, *e.g.*, Gode and Mohanram, 2003; Guay *et al*., 2003; Botosan and Plumlee, 2005; Easton and Monahan, 2005), we follow Dhaliwal *et al*. (2005) and Hail and Leuz (2006, 2009) and also report our results based on the equally-weighted average of the four implied cost of equity measures (denoted as R_{AVE}) to mitigate the effect of measurement errors from each model.[6] We choose the stock price at the end of four months after the fiscal year-end to estimate the implied cost of equity capital to ensure that financial data used to compute the independent variables and data on executive compensation are publicly available and fully priced at the time of the cost of equity computations.[7] To correct for partial-year discounting, we discount the stock price at the end of four months after the fiscal year-end by four months to the beginning of the fiscal year using the corresponding implied cost of equity capital. The four implied cost of equity models and the relevant variables are described in Appendix A.

3.2 CEO Compensation Portfolio Deltas and Vegas

We collect CEO compensation information from Standard and Poor's ExecuComp database. We define CEO compensation portfolio price sensitivity (*CEOPRICESEN or deltas*) as the change in the value of the CEO's stock and option portfolio in response to a 1 percent increase in the firm's stock price. We define CEO compensation portfolio volatility sensitivity (*CEOVOLSEN or vegas*) as the change in the value of the CEO's option portfolio in response to a 0.01 increase in the annualized standard deviation of the firm's stock return. We follow Guay (1999) and Core and Guay (2002) in calculating CEO compensation portfolio *deltas* and *vegas*. Essentially, the partial derivatives of the option price with respect to stock price (*delta*s) and stock return volatility (*vegas*) are based on the Black-Scholes (1973) option pricing model. A detailed discussion of the Core and Guay (2002) derivation of CEO compensation portfolio *deltas* and *vegas* is presented in Appendix B.

3.3 Control Variables

[6] In unreported tests, we also use the median of the estimates from the four models and our findings are insensitive to the use of the median instead of the mean.

[7] Most listed U.S firms publish their annual reports within four months after the fiscal year-end. The U.S. Securities and Exchange Commission (SEC) has required publicly traded companies to disclose information regarding executives' compensation to the market and also post compensation amounts on its website. Using the stock price four months after the fiscal year-end allows the market sufficient time to fully price information from financial reports. However, in unreported tests, our findings and conclusions in this study are unaffected when we replicate our analysis using cost of equity estimated at the fiscal year-end. The market appears to price information on managerial risk incentives instantaneously.

Following prior research, we employ eight variables to control for the effects from other known determinants of the cost of equity capital. We commence by including the three Fama and French (1996) risk factor loadings (β_{MKT}, β_{SMB}, and β_{HML}) employed in Dhaliwal *et al*. (2005) and Dhaliwal *et al*. (2006) to control for market risk, size risk, and book-to-market risk. The three risk factor loadings are estimated using a maximum of 60 weekly returns prior to the firm's fiscal year-end, and a minimum of 20 weeks.[8] We follow Gebhardt *et al*. (2001) and Gode and Mohanram (2003) and control for two properties of analysts' forecasts, *Disp* and *LTG* where *Disp* refers to dispersion in the one-year-ahead analysts' earnings forecast obtained from I/B/E/S, and *LTG* is the natural logarithm of I/B/E/S analysts' long-term growth in earnings forecasts.[9] Gebhardt *et al*. (2001) also include the book value-to-market ratio (*BM*) to control for undervalued stocks. They argue that undervalued stocks (high *BM*) should earn an abnormally high implied risk premium until the mispricing is corrected. We also control for the size effect by including *Size* in our model (Gebhardt *et al*., 2001; Gode and Mohanram, 2003; Dhaliwal *et al*., 2006), and *Size* is measured as the natural logarithm of a firm's market capitalization. We include leverage (*Leverage*) as the ratio of long-term debt over equity to control for the effect of financial leverage on the cost of equity capital. To control for the effect of outliers, we winsorize all variables at the 1st and 99th percentiles.

4. Descriptive Statistics

Table 1 reports descriptive statistics on the five implied cost of equity capital measures (R_{AVE}, R_{EAST}, R_{GLS}, R_{CT}, and R_{GM}), control variables and CEO compensation portfolio *deltas* and *vegas*. Our sample comprises of 11,041 firm-year observations spanning

[8] Our results are unaffected when we estimate the three risk factor loadings using a maximum (minimum) of 60 (20) monthly returns prior to the firm's fiscal year-end.

[9] Gebhardt *et al*. (2001) and Gode and Mohanram (2003) find that analysts' forecast properties explain cross-sectional variation in the implied equity risk premium.

the period 1992-2009 from which we compute CEO compensation portfolio *deltas, vegas* and the implied cost of equity capital.

[INSERT TABLE 1 ABOUT HERE]

The summary statistics for R_{AVE}, which is deduced as the average of the four implied cost of equity capital estimates, indicate that the mean (median) risk premium demanded by investors over our sample period is 9.5 percent (9.00 percent). Similar to other studies (e.g., Guay *et al*., 2005; Dhaliwal *et al*., 2006), statistics for the individual implied cost of equity measures indicate that the Gode and Mohanram (2003) and Easton (2004) models produce larger mean implied cost of equity estimates for our sample firms (9.87 and 11.14 percent respectively) in comparison with the estimate from the Claus and Thomas (2001) model (mean R_{CT} of 8.61 percent) and the estimate from the Gebhardt *et al*. (2001) model (mean R_{GLS} of 8.43 percent).

Other summary statistics indicate that our sample firms on average have a book-to-market ratio (*BM*) of approximately 59.28 percent. The mean long-term growth rate from analyst forecasts from I/B/E/S is around 15.26 percent, suggesting that analysts expect positive growth in investment opportunities for the sample firms. The average dispersion in analysts' earnings forecasts is 12.47 percent, reflecting notable uncertainty in the analysts' earnings forecasts. The average log of market capitalization of our sample firms is 7.72 and the average leverage is 21 percent. The average Fama-French risk factor loading is 0.9405, 0.2085, and 0.0581, respectively, for market risk, size risk, and book-to-market risk.

The CEO compensation portfolio sensitivities in Table 1 are in thousands of dollars. The mean (median) CEO's wealth increases by $719,000 ($140,000) for a 1 percent increase in stock price (*CEOPRICESEN*). The mean (median) CEO's wealth increases by $106,000 ($64,000) for a 0.01 increase in annual stock return volatility (*CEOVOLSEN*). The values of the CEO compensation portfolio sensitivities in our study are much larger than those reported in Guay (1999) and somewhat similar to those reported in Brockman *et al*. (2010) and Chava and Purnanandam (2010). This is because Guay's sample ends in 1993 while Brockman *et al*.'s sample and Chava and Purnanandam's sample span the period 1992 to 2005 and 1993 to 2005, respectively. Our sample period is the most comprehensive, covering the period 1992-2009. The increasing trend in grant stock options as part of executive compensation in the U.S markets over time explains the significant increase of CEO compensation portfolio sensitivity values in our study relative to those in Guay (1999). *CEOPRICESEN* and *CEOVOLSEN* exhibit positive skewness as their mean values are much higher than the corresponding median values. This skewness will not impede our empirical findings as we apply the natural logarithm of these dollar value sensitivities in subsequent regression analyses.

5. Empirical Results

5.1 Average Implied Cost of Equity Capital and CEO Compensation Portfolio Sensitivities

We commence our empirical analyses by employing a regression analysis to examine the cross-sectional relation between the average implied cost of equity capital and CEO compensation portfolio sensitivities.

In Table 2, we report the empirical results from various pooled regression models. Here, we take the natural logarithm of CEO compensation portfolio sensitivities for the regression analysis. We report two-way clustered *t*-statistics based on standard errors clustered by firm and year. According to H_1 and H_2, we expect a negative (positive) relation between the average cost of equity capital and the CEO compensation portfolio sensitivity to stock price (sensitivity to stock return volatility). In Table 2, we report the empirical results for four models. The regression results in model (1) support both hypotheses by showing that *LCEOPRICESEN*'s estimated coefficient is negative at -0.006 and *LCEOVOLSEN*'s estimated coefficient is positive at 0.0016, and both are highly significant (*t*-statistic of -5.23 and 3.66, respectively). In model (2), in which we include year fixed effect and industry fixed effect in the regression model, the estimated coefficients on *LCEOPRICESEN* and *LCEOVOLSEN* retain their signs and statistical significance. These findings suggest that high CEO compensation portfolio sensitivity to stock prices (*deltas*) is associated with a lower implied cost of equity capital while high CEO compensation portfolio sensitivity to stock return volatility (*vegas*) is associated with a higher implied cost of equity capital.

Models (3) and (4) in Table 2 include other control variables in the regression analysis. In both models, the estimated coefficients on *LCEOPRICESEN* and *LCEOVOLSEN* retain their negative (positive) signs and are highly significant. In model (3), the estimated coefficient on *LCEOPRICESEN* is -0.0044 (*t*-statistic of -3.91) and the estimated coefficient on *LCEOVOLSEN* is 0.0012 (*t*-statistic of 3.59). In model (4), in which we include both year fixed effect and industry fixed effect, the estimated coefficient on *LCEOPRICESEN* is -0.0035 (*t*-statistic of -4.14) and the estimated coefficient on *LCEOVOLSEN* is 0.0021 (*t*-statistic of 4.04). Thus, the negative (positive) relation between *LCEOPRICESEN* (*LCEOVOLSEN*) and the average implied cost of equity capital remains robust to the inclusion of other determinants of the cost of equity capital as well as fixed effects.

Besides results for our main variables of interest, the results reported in Table 2 also show consistent findings for control variables. The majority of control variables show the expected signs and are significant in explaining the average implied cost of equity capital. Specifically, the estimated coefficients on *BM*, *LTG*, *Disp*, *Leverage* and risk factor loadings are positive and the estimated coefficient on *Size* is negative. Model (4) with the inclusion of all control variables and fixed effects yields the best explanatory power with an *R*-squared value of 0.34.

The coefficients on *LCEOPRICESEN* and *LCEOVOLSEN* in Table 2 not only display high statistical significance but also show important economic significance. In model (1), in which we only include CEO compensation portfolio sensitivities as explanatory variables, the estimated effect on cost of equity capital, inferred from the estimated coefficients, suggests that there is a 60 basis point reduction in the average cost of equity capital, going from the 25^{th} to the 75^{th} percentile of *LCEOPRICESEN*, and a 16 basis point increase in the average cost of equity capital, going from the 25^{th} to the 75^{th} percentile of *LCEOVOLSEN*. In model (4), with the most comprehensive set of control variables and fixed effects, the effect on the average cost of equity capital is a 35 basis point reduction from *LCEOPRICESEN* and a 21 basis point increase from *LCEOVOLSEN*. We conclude that there is an economically significant relation between CEO compensation portfolio sensitivities and the average implied cost of equity capital.

[INSERT TABLE 2 ABOUT HERE]

5.2 Individual Implied Cost of Equity Capital and CEO Compensation Portfolio Sensitivities

Table 3 reports the regression results of model (4) in Table 2 (the full regression model with the inclusion of both control variables and fixed effects) for each of our four individual implied cost of equity capital measures. The estimated effect of *LCEOPRICESEN* on individual implied cost of equity ranges from a 21 basis point reduction (R_{GM}) to a 55 basis point reduction (R_{EAST}), going from the 25^{th} to the 75^{th} percentile of *LCEOPRICESEN*. The estimated coefficient on *LCEOPRICESEN* is highly significant in all regressions, with *t*-statistics ranging between -3.66 and -6.77.

The estimated effect on individual implied cost of equity capital from *LCEOVOLSEN* ranges from a 10 basis point increase (R_{GLS}) to a 26 basis point increase (R_{EAST}), going from the 25^{th} to the 75^{th} percentile of *LCEOVOLSEN*. The estimated coefficient on *LCEOVOLSEN* is also highly significant in all regressions, with *t*-statistics ranging between 2.23 to 5.15. The effects of *LCEOPRICESEN* and *LCEOVOLSEN* are strongest, as inferred from the size of the coefficient estimates, for the implied cost of equity capital estimated from the *PEG* model by Easton (2004) (R_{EAST}). The results for the control variables and the explanatory power of the regressions are comparable to those obtained with the average implied cost of equity capital in Table 2. The explanatory power of regression analysis ranges between 20 and 34 percent in Table 3.

To summarize, the results in Table 3 document that the negative (positive) relation between *LCEOPRICESEN* (*LCEOVOLSEN*) and the implied cost of equity capital is consistent and robust across a broad set of individual cost of equity capital measures.

[INSERT TABLE 3 ABOUT HERE]

5.3 Changes-in-Variables Analysis

In this section, we examine the robustness of the results obtained in the previous section by investigating the changes in variables as opposed to the levels of variables. We implement this analysis by regressing the annual change in the implied cost of equity capital on the annual change in CEO compensation portfolio sensitivities, after controlling for annual changes in the control variables. Weber (2006) suggests that the use of change-in-variables regressions can help address endogeneity concerns. Moreover, change-in-variables regressions are useful in mitigating problems with correlated omitted variables as we use the firm as its own control. We estimate the pooled regression using 9,293 firm-year observations over the period 1993-2009 for which annual changes in variables can be computed.

Table 4 presents the regression results for four models using the annual change in the average implied cost of equity capital on the left-hand side. In model (1), in which we include only annual changes in CEO compensation portfolio sensitivities as explanatory variables, we document a negative and significant estimated coefficient on *ΔLCEOPRICESEN* of -0.0233 (*t*-statistic of -4.82) and a positive and significant estimated coefficient on *ΔLCEOVOLSEN* of 0.0057 (*t*-statistic of 4.05). These findings support our prior testable hypotheses. In model (2), in which we include year fixed effect and industry fixed effect in the regression model, we document a negative and significant estimated coefficient on *ΔLCEOPRICESEN* (-0.0134 with *t*-statistic of -6.67) and a positive and significant estimated coefficient on *ΔLCEOVOLSEN* (0.004 with *t*-statistic of 3.90). In models (3) and (4), when changes in other control variables and fixed effects are included in the regressions, both the estimated coefficients on *ΔLCEOPRICESEN* and *ΔLCEOVOLSEN* retain their signs and statistical significance. The explanatory power of the changes-in-variable regressions ranges from 14 percent in model (1) to 21 percent in model (4). Taken together, the change-in-variables analysis confirms the earlier findings based on the levels of variables and support both H_1 and H_2.

[INSERT TABLE 4 ABOUT HERE]

We notice that the effects of the changes in *ΔLCEOPRICESEN* and *ΔLCEOVOLSEN* on the changes in the average implied cost of equity capital, inferred from the size of the estimated coefficients, are even of a stronger magnitude compared with the effects from the levels of variables. The magnitude of the estimated coefficient on *ΔLCEOPRICESEN* in model (4) of Table 4 (0.0146) is 4.17 times that of the estimated coefficient on *LCEOPRICESEN* in model (4) of Table 2 (0.0035). Likewise, the magnitude of the estimated coefficient on *ΔLCEOVOLSEN* in model (4) of Table 4 (0.0045) is 2.14 times that of the estimated coefficient on *LCEOVOLSEN* in model (4) of Table 2 (0.0021). Thus, the results in Table 4 suggest that the link between CEO risk-related incentives and the average cost of equity capital is not only evident but also highly economically important in the change specification.

Table 5 presents the regression results of annual change in individual implied cost of equity capital to a set of annual change in control variables and annual change in sensitivities of CEO compensation portfolios to stock price and stock return volatility. We show that the estimated coefficient on *ΔLCEOPRICESEN* ranges from -0.0098 (R_{CT}) to -0.0211 (R_{EAST}) and is significant across all four models (*t*-statistic ranging from -3.49 to -7.11). The estimated coefficient on *ΔLCEOVOLSEN* ranges from 0.0033 (R_{CT}) to 0.0049 (R_{EAST}) and is also significant across all four models (*t*-statistic ranging from 3.19 to 6.37). Here, the change-in-variables analysis for individual implied cost of equity capital measures is also consistent with that of the change-in-variables analysis for the average implied cost of equity capital. Similar to the results in Table 3, we also document that the effects of *ΔLCEOPRICESEN* and *ΔLCEOVOLSEN* on the cost of equity capital are strongest for R_{EAST}.

[INSERT TABLE 5 ABOUT HERE]

5.4 Ratio of CEO Vega over Delta and the Cost of Equity Capital

Prior research has employed the ratio of the CEO *vega* over *delta* as a consolidated measure of CEO risk-related incentive (see, *e.g.*, Rogers, 2002, 2005; Grant *et al*., 2009). Core *et al*. (2003) argue that risk taking is a second-order effect in a CEO option portfolio in which the incentive to increase the stock price dominates the incentive to take risk. Therefore, it is intuitively plausible to examine the proportion of the second-order effect with respect to the first-order effect and its effect on the cost of equity capital. Here, the ratio of the CEO *vega* over *delta*, denoted as *CEOSENRATIO*, measures the proportion of incentives to take risk with respect to the proportion of incentives to reduce risk. The higher the ratio, the higher the incentive to take risk. Hence, we expect a positive relation between *CEOSENRATIO* and the cost of equity capital.

Table 6 presents the regression results of five measures (R_{AVE}, R_{EAST}, R_{GLS}, R_{CT}, and R_{GM}) of the cost of equity capital against *CEOSENRATIO* with the inclusion of control variables and fixed effects. The estimated coefficient on *CEOSENRATIO* is 0.0086 and highly significant (*t*-statistic of 4.10) in the regression using the average implied cost of equity capital on the left-hand side. Thus, the effect on the average implied cost of equity capital is an 86 basis point increase, going from the 25^{th} percentile to the 75^{th} percentile of the ratio of the CEO *vega* over *delta*. When examining regressions of individual implied cost of equity measures, we also find that the estimated coefficient on *CEOSENRATIO* is positive (ranging between 0.0055 to 0.0135) and highly significant (*t*-statistic ranging from 2.55 to 3.95).

[INSERT TABLE 6 ABOUT HERE]

Overall, the results confirm that when we consolidate risk-taking incentives and risk-reducing incentives into one relative measure, there is a significant positive relation between CEO risk taking incentives and the implied cost of equity capital. In unreported tests in which we conduct change-in-variables analysis, we also find that the annual change in *CEOSENRATIO* is positively and significantly associated with the annual change in the implied cost of equity capital.

5.5 Robustness Analysis

In this section, we examine the relation between various alternative measures of executive compensation portfolio sensitivities and the implied cost of equity capital. For brevity, we only present regression results using the average implied cost of equity capital with the inclusion of all control variables and fixed effects. We present these results in Table 7 where the results are presented for six models.

In model (1), we replace our main definition of CEO compensation portfolio sensitivities with the top five managers' compensation portfolio sensitivities. We apply this alternative definition as corporate decisions and policy choices are often made in teams (Aggarwal and Samwick, 2003), and thus it is worthwhile to investigate whether and how aggregate managerial incentives influence the cost of equity capital. In model (1) the calculation of *delta*s and *vega*s is an aggregate of the dollar sensitivities to stock price and stock return volatility of the top five managers' stock and option portfolios (denoted as *LMGMPRICESEN* and *LMGMVOLSEN*, respectively). The estimated coefficient on *LMGMPRICESEN* is negative at -0.0047 and significant (*t*-statistic of -3.73) and the estimated coefficient on *LMGMVOLSEN* is positive at 0.0028 and significant (*t*-statistic of 3.70). The explanatory power of model (1) is 35 percent. Thus, results on the relation between the top five management compensation portfolio sensitivities and the average implied cost of equity capital are similar to earlier findings on the relation between CEO compensation portfolio sensitivities and the cost of equity capital.

In model (2), we consolidate the top five managers' compensation portfolio sensitivities into the ratio of top five managers' *vega* over *delta* and denote this variable as *MGMSENRATIO*. We document a positive and significant estimated coefficient on *MGMSENRATIO* (0.0162 with a *t*-statistic of 3.82). This finding is in line with prior findings on the relation between the CEO's *vega* over *delta* ratio and the cost of equity capital.

In model (3), we separate the CEO's *delta* into stock portfolio *delta* (denoted as *LCEOPRICESEN_STOCK*) and option portfolio *delta* (denoted as *LCEOPRICESEN_OPTION*). We find that both stock and option *deltas* are negatively related to the average implied cost of equity capital. The estimated coefficient on *LCEOPRICESEN_STOCK* is -0.0007 and significant at the 10 percent level and the estimated coefficient on *LCEOPRICESEN_OPTION* is -0.0048 and significant at the 1 percent level. Here, we notice that the effect of the option compensation portfolio *delta* on the cost of equity capital is much more pronounced than that of the stock compensation portfolio *delta*. The magnitude of the estimated coefficient on *LCEOPRICESEN_OPTION* is 6.8 times that of the estimated coefficient on *LCEOPRICESEN_STOCK*.[10]

In model (4), we examine the effects of the CEO stock *delta* (*LCEOPRICESEN_STOCK*), exercisable option *delta* (*LCEOPRICESEN_EXOPTION*), and exercisable option *vega* (*LCEOVOLSEN_EXOPTION*) on the average implied cost of equity capital. We continue to find a negative relation between *deltas* and the cost of equity capital and a positive relation between *vegas* and the cost of equity capital. In model (5), we conduct similar analysis as in model (4) using non-exercisable options and report similar findings. In model (6), we include CEO stock *delta*, *deltas* and *vegas* from both exercisable options and non-exercisable options in the regression model. The estimated coefficient is -0.0008 (*t*-statistic of -2.19) for CEO stock *delta*, -0.0025 (*t*-statistic of -3.19) for CEO exercisable option *delta*, and -0.0036 (*t*-statistic of -3.29) for CEO non-exercisable option *delta*. Thus, all three *deltas* are significantly and negatively related to the average cost of equity capital. The effect on the average implied cost of equity capital is strongest for CEO's non-exercisable option *delta* and smallest for CEO's stock portfolio *delta*. This finding is intuitively plausible as non-exercisable options should impose the greatest incentive on CEO risk-taking behavior and thus have the strongest effect on the implied cost of equity capital. The estimated

[10] We conduct a statistical test of the null hypothesis that the estimated coefficient on *LCEOPRICESEN_OPTION* is equal to the estimated coefficient on *LCEOPRICESEN_STOCK* and reject this null hypothesis (*p*-value<0.001). Thus, option *delta* exerts effects of a different magnitude on the average cost of equity capital as compared with stock *delta*.

coefficient on CEO's *vegas* is 0.0017 and significant (*t*-statistic of 2.81) for exercisable option *vega* and 0.0040 and significant (*t*-statistic of 3.34) for non-exercisable option *vega*. Here, we also notice a higher effect on the average cost of equity capital from CEO's non-exercisable option *vega* than from CEO's exercisable option *vega*.[11]

In summary, the analysis in Table 7 consistently shows a negative and significant relation between executive compensation portfolio *deltas* and the average cost of equity capital and a positive and significant relation between executive compensation portfolio *vegas* and the average cost of equity capital. Other notable results in Table 7 are that option *deltas* have a stronger effect on the cost of equity capital than stock *deltas* and that *deltas* and *vegas* from non-exercisable options have stronger effects on the cost of equity capital than those from exercisable options.

[INSERT TABLE 7 ABOUT HERE]

5.6 Endogeneity

The analyses thus far treat CEO compensation portfolio sensitivities as exogenous in modelling the implied cost of equity capital. It is possible, however, that CEO compensation portfolio sensitivities are endogenous. This endogeneity might arise if an omitted variable correlated with CEO compensation portfolio sensitivities and the cost of equity capital drive the results in the study or if the cost of equity capital determines how firms establish their

[11] We conduct two statistical tests for model (6) in Table 7: i) whether the estimated coefficient on *LCEOPRICESEN_EXOPTION* is equal to the estimated coefficient on *LCEOPRICESEN_NONEXOPTION*, and ii) whether the estimated coefficient on *LCEOVOLSEN_EXOPTION* is equal to the estimated coefficient on *LCEOVOLSEN_NONEXOPTION*. We reject the null hypothesis in both tests (*p*-value<0.001) and conclude that the sensitivities of non-exercisable options exert effects of a different magnitude on the average cost of equity capital as compared with the sensitivities of exercisable options.

CEO stock and option incentive contracts.[12] In this section, we address endogeneity concerns in three different ways.

First, we follow Klein (1998) to address the concern of reverse causality (*i.e.*, CEO risk incentives in the compensation contract might be affected by the cost of equity capital in the previous period). We include the lagged cost of equity capital variable in the regression analysis. If the estimated coefficient on *LCEOPRICESEN* (*LCEOVOLSEN*) remains significantly negative (positive) after including the lagged cost of equity capital, we can reject the possibility of reverse causality to a certain extent. Model (1) in Table 8 presents the results of this analysis and confirms our findings reported in Table 2. More specifically, although the estimated coefficient on *LCEOPRICESEN* (*LCEOVOLSEN*) is reduced by about 28 (14) percent from 0.0035 (0.0021) in model (4) in Table 2 to 0.0024 (0.0018) in model (1) in Table 8, it is still significant (*t*-statistic of -5.23 and 3.89, respectively) when the lagged average cost of equity capital is included in the regression as a control variable.[13]

[INSERT TABLE 8 ABOUT HERE]

Second, we compute CEO compensation portfolio *deltas* and *vegas* from stocks and options previously granted and exclude stocks and options granted for the current fiscal year. Using the CEO compensation portfolio sensitivity variables computed from data several years before the current fiscal year makes it less likely that CEO compensation portfolio *deltas* and *vegas* are determined simultaneously with the current implied cost of equity capital. We present these results under model (2) in Table 8. We find that the estimated

[12] Larcker (2003) suggests that most studies employing a managerial choice variable as an explanatory variable face endogeneity concerns. Bhagat and Black (2002) also claim that studies examining variables capturing corporate ownership and other corporate aspects such as performance and capital structure are interrelated. In equilibrium, it is likely that these variables are jointly determined based on several firm-specific factors (John and John, 1993).

[13] The results on other control variables are consistent with earlier findings in this study. For brevity in presentation, we do not report the estimated coefficients and *t*-statistics for other control variables.

coefficient on $LCEOPRICESEN_{t-1}$ is negative at -0.0020 and significant (*t*-statistic of -3.43) while the estimated coefficient on $LCEOVOLSEN_{t-1}$ is positive at 0.0018 and also significant (*t*-statistic of 2.78). While the magnitude of estimated coefficients drops considerably for both variables, there remain statistically and economically significant relations between CEO *deltas* and *vegas* from the prior year and the average cost of equity capital.[14]

In our final approach, we employ a two-stage least squares regression analysis and treat CEO compensation portfolio sensitivities as endogenous variables to formally tackle endogeneity concerns. We use a comprehensive set of instrumental variables suggested by prior studies (Himmelberg *et al*., 1999; Knopf *et al*., 2002; Coles *et al*., 2006; Ortiz-Molina, 2006; and Brockman *et al*., 2010) to model CEO compensation portfolio sensitivities. In addition to using control variables for the implied cost of equity capital as exogenous variables, our set of instrumental variables here includes: *LTENURE* as the natural logarithm of the CEO's tenure measured in years; *SURCASH* as the cash from assets-in-place; *VOL_RISK* as the natural logarithm of monthly stock return variance during the fiscal year; *LCASHCOMP* as the natural logarithm of the sum of the CEO's salary and bonus; *SGR* as the sales growth rate; *LRD* as the natural logarithm of research and development expenses divided by sales; *LCAPX* as the natural logarithm of capital expenditure divided by total assets and *BHRET* as the buy-and-hold stock return during the fiscal year. First, we can treat these instrumental variables as exogenous as there is no theoretical link for the relation between these instruments and the cost of equity capital. Second, we compute a test of over-identifying restrictions to evaluate the appropriateness of the instruments as recommended in Larcker and Rasticus (2010) since we have multiple instruments for each endogenous variable. The Sargan test of over-identifying restrictions does not reject the exogeneity of

[14] In models (1) and (2) in Table 8, the sample size reduces to 9,293 firm-year observations due to the requirement of lagged data.

instruments (χ^2 =0.48 and p-value=0.43).[15] The data requirements to compute instrumental variables reduce the sample size in this analysis to 8,471 firm-year observations.

In the first-stage regressions, *LCEOPRICESEN* and *LCEOVOLSEN* are each separately regressed on the exogenous variables and the instrumental variables listed above. The *R*-squared value from the first-stage regressions is 0.80 for *LCEOPRICESEN* and 0.77 for *LCEOVOLSEN*. In the second-stage regression, we use the predicted values of *LCEOPRICESEN* and *LCEOVOLSEN* from each of these separate first-stage OLS regressions. Model (3) in Table 8 presents the results of the second-stage regression. The estimated coefficients on *Pr(LCEOPRICESEN)* and *Pr(LCEOVOLSEN)* in the second-stage regression are of lower magnitude than, but comparable to, those in the OLS regression in model (4) of Table 2. These coefficients retain their signs and are statistically significant at the 1 percent level.

Overall, while CEO risk incentives are firm's choices and may be determined by several firm-specific factors, the results from Table 8 generally indicate that the negative (positive) relation between CEO *deltas* (*vegas*) and the implied cost of equity capital in our study does not appear to be driven by the endogeneity of these risk incentives.

5.7 Tests on the Cost of External Equity Financing

We investigate the effects of CEO risk incentives on the cost of equity capital in a context in which we can directly measure the cost of raising equity capital, the documented underpricing of seasoned equity offerings (SEOs). SEO underpricing occurs when the offer

[15] The tests of the appropriateness of instrumental variables are based on the assumption that at least one of the instruments is valid (Larcker and Rasticus, 2010). We acknowledge that there might be a possibility that all instrumental variables are biased in the same direction and the test of over-identifying restrictions does not reject the null of appropriateness of instruments even though the instrumental variable estimates are biased.

price is lower than the closing price on the day prior to the offer date and represents a substantial cost of issuing new shares (Altinkilic and Hansen, 2003).

SEO underpricing offers an effective setting to examine the relation between CEO risk incentives and the cost of equity capital for two reasons. First, prior research has shown that the use of implied cost of equity capital is subject to measurement errors (Joos, 2000; Easton and Monahan, 2005) because the valuation models rely on imperfect analyst earnings forecasts and simplified assumptions regarding earnings forecasts beyond the analysts' forecast horizons. SEO underpricing is a direct measure of the cost of raising equity capital and can be accurately and directly measured, thereby ruling out any measurement error issue.[16] Second, investigation of SEO underpricing offers another powerful way to tackle endogeneity concerns because the underpricing of SEOs occurs on the offer date and is unlikely to affect the CEO compensation contract prior to this date.[17] Our hypothesis in this analysis is that CEO *deltas* (*vegas*) are negatively (positively) related to SEO underpricing.

We collect the initial sample of 8,294 SEOs of common shares in the period from 1993 to 2009 from the Securities Data Company (SDC).[18] We then apply various restrictions on the sample as in Bowen *et al*. (2009) and also require that data on CEO risk incentives from the prior year are available for each SEO.[19] As a result, the final sample includes 1,112 SEO issues spanning the period 1993-2009.

[16] We acknowledge that the underpricing of SEOs is only one of several components of the cost of raising equity capital in SEOs. For example, underwriting fees and price changes around SEO announcements also represent significant costs. Bowen *et al*. (2009), however, posit that SEO underpricing is the most representative of the cost of raising equity capital.

[17] The final offer price for SEOs is often set after the stock market closes on the day prior to the offer date. The underpricing of SEOs occurs when the offer price is less than the closing market price on the day prior to the offer date, representing a cost of raising equity capital for the issuers (Altinkilic and Hansen, 2003).

[18] We select the beginning sample period to be in year 1993 so that we can use CEO risk incentives in 1992 to relate to SEO underpricing in 1993.

[19] Specifically, we require that i) SEO issues must include some primary offerings, ii) SEO issues must have data available in CRSP, iii) the offer price is between $5 and $4000 to eliminate illiquid firms, and iv) SEO issues have analyst coverage in the IBES Detailed Earnings Forecast file.

We compute CEO *deltas* and *vegas* from the year prior to the SEOs to relate to SEO underpricing. Similar to prior studies, we define underpricing as the return from the closing price on the day immediately before the offer date to the offer price.[20] We also employ a set of control variables as determinants of SEO underpricing: firm size (*Size*) as the natural log of the market value of equity at the end of the year before the SEOs, number of analysts covering the firms (*#N_Analyst*) in the year before the SEO, idiosyncratic volatility (*Idio_Vol*) as the natural log of the standard deviation of the residuals from the regression of monthly returns on Fama and French (1996) risk factors in the five years before the SEOs, relative offer size (*Relative_Offer_Size*) as the offer size relative to outstanding shares, positive pre-offer abnormal return (*CAR_Positive*) as the cumulative abnormal return in the 10 days leading to the offer date if this is a positive value, negative pre-offer abnormal return (*CAR_Negative*) as the cumulative abnormal return in the 10 days leading to the offer date if this is a negative value, the rounding of the offer price to a $0.25 increment (*Tick[0,0.25]*), stock price 10 days prior to the offer date (*Price*), and a dummy variable for NYSE stocks (*NYSE*).[21]

Table 9 presents the regression results of SEO underpricing on CEO compensation portfolio sensitivities and control variables. In model (1), which excludes control variables

[20] Safieddine and Wilhelm (1996) suggest that some offer dates in SDC are incorrect because the offers occur after-hours. We employ the volume-based adjustment in Altinkilic and Hansen (2003) and Corwin (2003) to correct for possible errors in the SDC offer dates. Essentially, if we find that trading volume on the day after the SDC offer date is more than twice that on the SDC offer date and more than twice the average daily trading volume in the 250 days leading to the SDC offer date, we shift the 'actual' offer date to the trading day following the SDC offer date. Corwin (2003) confirms high accuracy in the adjustment of SDC offer dates using trading volume.

[21] Corwin (2003) suggests that firm size can act as a proxy for information asymmetry and is negatively related to SEO underpricing. Bowen *et al*. (2009) document a negative relation between the number of analysts covering the firm and SEO underpricing because asymmetric information risk is reduced. Beatty and Ritter (1986) suggest that underpricing is larger for firms with high return volatility. Corwin (2003) uses the offer size relative to outstanding shares as a proxy for the price pressure and finds higher underpricing for firms with a relatively large offer size. Gerard and Nanda (1993) and Corwin (2003) use pre-offer cumulative returns to measure price manipulation by investors. Mola and Loughran (2004) suggest that the underpricing of SEOs should be larger for firms with offer prices that are not at a $0.25 increment. Corwin (2003) and Bowen *et al*. (2009) show some difference in underpricing for NYSE firms.

and fixed effects, the estimated coefficient on *LCEOPRICESEN* is -0.0058 and significant (*t*-statistic of -3.17). Thus, there is strong evidence that CEO *deltas* are associated with a lower cost of external equity finance as *deltas* are inversely related with SEO underpricing. The estimated coefficient on *LCEOVOLSEN* is positive at 0.0013 but insignificant (*t*-statistic of 0.91). Model (2) includes fixed effects but excludes control variables. Here, we find an even stronger estimated coefficient on *LCEOPRICESEN* (-0.0079 with *t*-statistic of -3.97). The estimated coefficient *LCEOVOLSEN* is positive and continues to be insignificant. In model (3) in which control variables are included and in model (4) in which both control variables and fixed effects are included, our main findings on *LCEOPRICESEN* and *LCEOVOLSEN* are generally similar to those reported in models (1) and (2). The estimated coefficients on control variables are generally in line with expected signs and prior studies. We find that analyst coverage and stock prices are significantly associated with lower SEO underpricing while idiosyncratic volatility, relative offer size, and negative pre-offer cumulative abnormal return are significantly associated with higher SEO underpricing. The explanatory power of the regression analysis of SEO underpricing in Table 9 varies from 2 percent in model (1) to 19 percent in model (4).

[INSERT TABLE 9 ABOUT HERE]

To summarize, in the setting of SEOs where the cost of raising external equity can be directly measured from SEO underpricing, we find that CEO *deltas* are negatively related to SEO underpricing and thus lead to a lower cost of external equity financing. This result echoes the negative relation between CEO *deltas* and the implied cost of equity capital from earlier findings. We, however, do not document a significant relation between CEO *vegas* and SEO underpricing.

6. Conclusion

Recent studies posit that managerial stock and option compensation portfolios exhibit two opposing effects on managerial risk-taking behaviour (Knopf *et al*., 2002; Coles *et al*., 2006; Brockman *et al*., 2010). *Deltas,* the sensitivity of CEO compensation portfolio to stock price, discourage managerial risk-taking behavior while *vegas*, the sensitivity of CEO's compensation portfolio to stock return volatility, encourage managerial risk-taking behavior. A growing body of empirical research provides evidence that CEO compensation portfolio sensitivities determine the risk-taking behavior of CEOs and the firm's overall risk (Knopf *et al*., 2002; Rajgopal and Shevlin, 2002; Coles *et al*., 2006; Grant *et al*., 2009; Brockman *et al*., 2010; Armstrong and Vashishtha, 2011). In this study, we investigate whether shareholders price CEO risk-related incentives arising from CEO compensation portfolio sensitivities in the implied cost of equity capital. We hypothesize that CEO compensation portfolio sensitivity to stock price (stock return volatility) results in incentives to reduce (increase) the overall risk of a firm and therefore is associated with a lower (higher) cost of equity capital.

To test our hypotheses, we employ a sample of 11,041 firm-year observations over the period 1992 to 2009. We use four individual measures of implied cost of equity capital from four valuation models in the literature: Claus and Thomas (2001), and Gebhardt *et al*. (2001), Gode and Mohanram (2003) and Easton (2004) and an average-based measure of implied cost of equity capital. We follow Core and Guay (2002) in estimating option sensitivities of CEO compensation portfolio. Our findings show strong empirical support for both hypotheses. We find a consistently negative relation between CEO compensation portfolio sensitivity to stock price (*deltas*) and the cost of equity capital. We also find a consistently positive relation between CEO compensation portfolio sensitivity to stock return volatility (*vegas*) and the cost of equity capital.

In a change-in-variables analysis, we document that the annual change in CEO's *deltas* (*vegas*) is significantly and negatively (positively) associated with the annual change in the cost of equity capital. When consolidating *vegas* and *deltas* into a ratio that measures the overall CEO risk-taking incentive as in Rogers (2002, 2005) and Grant *et al*. (2009), we find that the ratio of the CEO *vega* over *delta* is significantly and positively related to the cost of equity capital. The negative (positive) relation between *deltas* (*vegas*) and the cost of equity capital is also robust to the examination of the top five managers' compensation portfolio sensitivities, the break-down of *delta*s into stock *delta* and option *delta*, and the separation of option *deltas* and *vegas* between exercisable options and non-exercisable options. Our main findings are also robust to various tests of endogeneity on the relation between CEO risk incentives and the cost of equity capital. In a setting of SEOs, we document that CEO *deltas* are inversely related to SEO underpricing and conclude that high *deltas* are associated with a lower cost of external equity financing. We find a positive but insignificant relation between CEO *vegas* and the cost of external equity financing.

Our study offers significant contributions to the literature on the executive compensation and the cost of equity capital. We show that CEO compensation portfolio sensitivities affect the implied cost of equity capital in opposite directions. These findings are consistent with the notion that CEO compensation portfolio sensitivities exert opposite effects on the firm's overall risk. Our findings also add new evidence to the literature on the cost of equity capital, namely that CEO compensation portfolio sensitivities are significant determinants, both statistically and economically. These findings highlight the important role that CEO risk-taking behavior plays in market-based assessments of firms.

References

Agrawal, A. and G. N. Mandelker, 1987, Managerial incentives and corporate investment and financing decisions, *Journal of Finance* 42, 823-837.

Aggarwal, R. K. and A. A. Samwick, 2003, Performance incentives within firms: the effect of managerial responsibility, *Journal of Finance* 58, 1613-1650.

Altinkilic, O., and R. S. Hansen, 2003, Discounting and underpricing in seasoned equity offers, *Journal of Financial Economics* 69, 285-323.

Armstrong, C. S., and R. Vashishtha, 2011, Executive stock options, differential risk-taking incentives, and firm value, *Journal of Financial Economics*, forthcoming.

Baker, G. P., M. C. Jensen, and K.J., Murphy, 1988, Compensation and incentives: practice vs. theory, *Journal of Finance* 43, 593-616.

Barnea, A., R. A., Haugen, and L.W., Senbet, 1980, A rationale for debt maturity agency costs, and ownership structure, *Journal of Financial Economics* 3, 305-360.

Beatty, R. P., and J. R. Ritter, 1986, Investment banking, reputation, and the underpricing of initial public offerings, *Journal of Financial Economics* 15, 213-232.

Beatty, R., and E. Zajac, 1994, Managerial incentives, monitoring, and risk bearing. A study of executive compensation, ownership, and board structure in initial public offerings, *Administrative Science Quarterly* 39, 313–335.

Bebchuk, L., and Y. Grinstein, 2005, The growth of executive pay, *Oxford Review of Economic Policies* 21, 283-303.

Berle A.A., and C.G. Means, 1932, The modern corporate and private property, McMillian, New York, NY.

Bernadette M., and C. M., Schrand, 1999, The impact of cash flow volatility on discretionary investment and the costs of debt and equity financing, *Journal of Financial Economics* 54, 423-460.

Bhagat, S., and Black, B., 2002, The non-correlation between board independence and long term firm performance, *Journal of Corporation Law* 27, 231-274.

Billett, M., D. C., Mauer, and Y. Zhang, 2010, Stockholder and bondholder wealth effects of CEO incentive grants, *Financial Management* 39, 463-487.

Black, F., and M. Scholes, 1973, The pricing of options and corporate liabilities, *Journal of Political Economy* 81, 637–654.

Bliss, R. T. and R. J. Rosen, 2001, CEO compensation and bank mergers, *Journal of Financial Economics* 61, 107-138.

Botosan, C., 1997, Disclosure level and the cost of equity capital, *The Accounting Review* 72, 323–349.

Botosan, C., and M. Plumlee, 2002, A re-examination of disclosure level and the expected cost of equity capital, *Journal of Accounting Research* 40, 21–40.

Botosan, C., M. Plumlee, and Y. Xie., 2004, The role of private information in determining the cost of equity capital, *Review of Accounting Studies* 9, 233–259.

Botosan, C., and M. Plumlee, 2005, Assessing alternative proxies for the expected risk premium, *The Accounting Review* 80, 21-53.

Bowen, M.R., X. Chen, and Q. Cheng, 2008, Analyst coverage and the cost of raising equity capital: evidence from underpricing of seasoned equity offerings, *Contemporary Accounting Research* 25, 1-49.

Carpenter, J. N., 2000, Does option compensation increase managerial risk appetite?, *Journal of Finance* 55, 2311-2331.

Chava, S. and A. Purnanandam, 2010, CEOs vs. CFOs: Incentives and corporate policies, *Journal of Financial Economics* 97, 263-278.

Chen, K. C., Z. Chen, and K. C. Wei., 2004, Disclosure, corporate governance, and the cost of equity capital in emerging markets, Working paper, Hong Kong University of Science & Technology.
Cheng, Q., and T. D. Warfield, 2005, Equity incentive and earnings management, *The Accounting Review* 80, 441–476.
Claus, J. and J. Thomas, 2001, Equity premia as low as three percent? Evidence from analysts' earnings forecasts for domestic and international stock markets, *Journal of Finance* 56, 1629-1666.
Cohen, D., 2004, Quality of financial reporting choice: Determinants and economic consequences, Working paper, Northwestern University.
Coles, J. L., N. D., Daniel, and L. Naveen, 2006, Managerial incentives and risk taking, *Journal of Financial Economics* 79, 431-468.
Core, J. E., and W. R. Guay, 2002, Estimating the value of employee stock option portfolios and their sensitivities to price and volatility, *Journal of Accounting Research* 40, 613–630.
Core, J. E, W. R. Guay, and R. E. Verrecchia, 2003, Price versus non-price performance measures in optimal CEO compensation contracts, *The Accounting Review* 78, 957-981.
Corwin, S. A., 2003, The determinants of underpricing for seasoned equity offers, The *Journal of Finance* 58, 2249-79.
DeFusco, R. A., R. R. Johnson, and T. S. Zorn, 1990, The effect of executive stock option plans on stockholders and bondholders, *Journal of Finance* 45, 617-627.
Demsetz, H., 1983, The structure of ownership and the theory of the firm, *Journal of Law and Economics* 26, 375–390.
DeYoung, R., Peng, E.Y., and M. Yan, 2010, Executive compensation and policy choices at US commercial banks, Federal Reserve Bank of Kansas City Research Working Paper.
Dhaliwal, D.S, L. Krull, O.Z. Li, and W. Moser, 2005, Dividend taxes and implied cost of equity capital, *Journal of Accounting Research* 43, 675-708.
Dhaliwal, D.S., O. Z. Li, A. Tsang, and Y.G. Yang, 2010, Voluntary nonfinancial disclosure and the cost of equity capital: the initiation of corporate social responsibility reporting, *The Accounting Review* 86, 59-100.
Dhaliwal, D.S., S. Heitzman, and O.Z. Li, 2006, Taxes, leverage, and the cost of equity capital, *Journal of Accounting Research* 44, 691-723.
Diamond, D., and R. Verrecchia, 1991, Disclosure, liquidity and the cost of equity capital, *Journal of Finance* 46, 1325-1360.
Easton, P.D., 2004, PE ratios, PEG ratios, and estimating the implied expected rate of return on equity capital, *The Accounting Review* 79, 73-95.
Easton, P.D., and S.J. Monahan, 2005, An evaluation of accounting-based measures of expected returns, *The Accounting Review* 80, 501-538.
Fama, E. F., 1980, Agency problems and the theory of the firm, *Journal of Political Economy* 88, 288-307.
Fama, E. F. and K. R. French, 1992, The cross-section of expected stock returns, *Journal of Finance* 47, 427-465.
Fama, E. F., and K. French, 1996, Multifactor explanations of asset pricing anomalies, *Journal of Finance* 51, 55–84.
Fama, E.F., and K. French, 1997, Industry costs of equity, *Journal of Financial Economics* 43, 153–193.
Francis, J., R. LaFond, P.M. Olsson, and K. Schipper, 2004, Costs of equity and earnings attributes, *The Accounting Review* 79, 967-1010.
Feltham, G. A. and J. A. Ohlson, 1995, Valuation and clean surplus accounting for operating and financial activities, *Contemporary Accounting Research* 11, 689-731.

Gebhardt, W., C. Lee, and B. Swaminathan, 2001, Toward an implied cost of capital, *Journal of Accounting Research* 39, 135-176.
Gerard, B., and V. Nanda, 1993, Trading and manipulation around seasoned equity offerings, *Journal of Finance* 48, 213-45.
Gode, D. and P. Mohanram, 2003, Inferring the cost of capital using the Ohlson-Juettner model, *Review of Accounting Studies* 8, 399-431.
Graham, J. R., C. R. Harvey, and S. Rajgopal, 2005, The economic implication of corporate financial reporting, *Journal of Accounting and Economics* 40, 3–73.
Grant, J., G. Markarian, and A. Parbonett, 2009, CEO risk-related incentives and income smoothing, *Contemporary Accounting Research* 26, 1029-1065.
Guay, W. R, 1999, The sensitivity of CEO wealth to equity risk: An analysis of the magnitude and determinants, *Journal of Financial Economics* 53, 43–71.
Hagendorff, J., and F. Vallascas, 2011, CEO pay incentives and risk-taking: evidence from bank acquisitions, *Journal of Corporate Finance* 17, 1078-1095.
Hail, L., and C. Leuz, 2006, International differences in cost of equity: Do legal institutions and securities regulation matter? *Journal of Accounting Research* 44, 485-531.
Hall B.J., and J.B. Liebman, 1998, Are CEOs really paid like bureaucrats?, *Quarterly Journal of Economics* 112, 653-691.
Hanlon, M., S. Rajgopal, and T. J. Shevlin, 2004, Large sample evidence on the relation between stock option compensation and risk taking, Working paper, University of Washington.
Himmelberg, C.P., R.G. Hubbard, and D. Palia, 1999, Understanding the determinants of managerial ownership and the link between ownership and performance, *Journal of Financial Economics* 53, 353-384.
Holmstrom, B, 1979, Moral hazard and observability, *Bell Journal of Economics* 10, 74-91.
Huges J.S, J. Liu, and J. Liu, 2007, Information asymmetry, diversification, and cost of capital, *The Accounting Review* 82, 705-729.
Jensen, M. C., and W. H. Meckling, 1976, Theory of the firm: managerial behavior, *Journal of Finance* 48, 949-974.
John, T., and K. John, 1993, Top-management compensation and capital structure, *Journal of Finance* 55, 2311-2331.
Joos, P., 2000, Discussion of "The economic consequences of increased disclosures.", *Journal of Accounting Research* 38, 125-36.
Klein, A., 1998, Firm performance and board committee structure, *The Journal of Law and Economics* 41, 275-303.
Knopf, John D., J. Nam, and J. H. Thornton Jr., 2002, The volatility and price sensitivities of managerial stock option portfolios and corporate hedging, *Journal of Finance* 57, 80-812.
Lambert, R. A, 1986, Executive effort and the selection of risky projects, *Journal of Economics* 17, 77–88.
Lambert, R.A., and D. F. Larcker, 2004, Stock options, restricted stock, and incentives, Working paper, University of Pennsylvania.
Lambert, R. A., D. F. Larcker, and R. E. Verrecchia, 1991, Portfolio considerations in valuing executive compensation, *Journal of Accounting Research* 29, 129– 149.
Lambert, R., C. Leuz, and R.E. Verrecchia, 2007, Accounting information, disclosure, and the cost of capital, *Journal of Accounting Research* 45, 385-420.
Larcker, D.F, 2003, Discussion of 'Are executive stock options associated with future earnings?, *Journal of Accounting and Economics* 36, 91-103.
Larcker, D.F., and T.O., Rasticus, 2010, On the use of instrumental variables in accounting research, *Journal of Accounting and Economics* 49, 186-205.

Leuz, C., and R. E. Verrecchia, 2000, The economic consequences of increased disclosure, *Journal of Accounting Research* 38, 91-124.

Liu Y., and D. C. Mauer, 2011, Corporate cash holdings and CEO compensation incentives, *Journal of Financial Economics* forthcoming.

Mehran, H., Rosenberg, J.V., 2007, The effect of employee stock options on bank investment choice, borrowing, and capital, Federal Reserve Bank of New York Report No. 305.

Minnick, K. and M. Zhao, 2009, Backdating and director incentives: money or reputation? *Journal of Financial Research* 32, 449-477.

Mola, S., and T. Loughran, 2004. Discounting and clustering in seasoned equity offering prices, *Journal of Financial and Quantitative Analysis* 39, 1-24.

Murphy, K.J, 1999, Executive pay, Handbook of Labour Economics, North Holland.

Naiker V., F. Navissi, and C. Truong, 2011, Options trading and the cost of equity capital, Working Paper, Monash University.

Nam, J., Ottoo, R., Thornton Jr, J., 2003, The effect of managerial incentives to bear risk on corporate investment and R&D investment, *Financial Review* 38, 77-101.

Nikolaev, V., and L. van Lent, 2005, The endogeneity bias in the relation between cost-of-debt capital and corporate disclosure policy, *European Accounting Review* 14, 677–724.

Ohlson, J, 1995, Earnings, book values, and dividends in equity valuation, *Contemporary Accounting Research* 11, 661–687.

Ohlson, J., and B. Juettner-Nauroth, 2005, Expected EPS and EPS growth as determinants of value, *Review of Accounting Studies* 10, 349–365.

Ortiz-Molina, H., 2006, Top-management incentives and the pricing of corporate public debt, *Journal of Financial and Quantitative Analysis* 77, 317-340.

Rajgopal, S., and T. Shevlin, 2002, Empirical evidence on the relation between stock option compensation and risk taking, *Journal of Accounting and Economics* 33, 145–171.

Rogers, D. A., 2002, Does executive portfolio structure affect risk management? CEO risk-taking incentives and corporate derivatives usage, *Journal of Banking and Finance* 26, 271-295.

Rogers, D. A., 2005, Managerial risk-taking incentives and executive stock option repricing: A study of US casino executives, *Financial Management* 34, 95–121.

Ross, S., 2004, Compensation, incentives, and the duality of risk aversion and riskiness, *Journal of Finance* 59, 207-225.

Safieddine, A., and W. J. Wilhelm, Jr, 1996, An empirical investigation of short-selling activity prior to seasoned equity offerings, *Journal of Finance* 51, 729-49.

Shavell, S., 1979, Risk sharing and incentives in the principal agent relationship, *The Bell Journal of Economics*, 55-73.

Smith, C. W., and R. M. Stulz. 1985. The determinants of firms' hedging policies, *Journal of Financial and Quantitative Analysis* 20, 391–405.

Stiglitz, J. E., 1987, The causes and consequences of the dependence of quality on price, *Journal of Economic Literature* 25, 1-48.

Strobl, G., 2003, Managerial compensation, market liquidity, and the over-investment problem, working paper, University of Pennsylvania.

Stulz, R., 1984, Optimal hedging policies, *Journal of Financial and Quantitative Analysis* 19, 127–140.

Tufano, P., 1996, Who manages risk? An empirical examination of risk management practices in the gold mining industry, *Journal of Finance* 51, 1097–1137.

Verdi, R., 2006, Information Environment and the Cost of Equity Capital, Working Paper, Massachusetts Institute of Technology.

Weber, J., 2006, Discussion of the effects of corporate governance on firms' credit ratings, *Journal of Accounting and Economics* 42, 245-254.

Appendix A

Implied Cost of Equity Capital Measures

To estimate the implied cost of equity capital, we apply the four following models developed by Easton (2004), Gode and Mohanram (2003), Claus and Thomas (2001), and Gebhardt *et al*. (2001):

P_t= Stock price after the latest fiscal year-end at time t. We use stock price four months after the latest fiscal year-end (P_{t+4}) to compute P_t. To account for partial year discounting, we estimate stock price at time t by discounting P_{t+4} by $(1+R)^{4/12}$ where R is the implied cost of equity capital.

BV_t= Book value of equity from the most recent available financial statement at time t.

$FEPS_{t+i}$= Analyst forecasted earnings per share from IBES for the next i years.

k= Forecasted dividend payout ratio where k is the dividend payout ratio calculated as the actual dividends per share at the beginning of year t (DPS_{t-1}) divided by the actual earnings per share at the beginning of fiscal year t (EPS_{t-1}).

1. The Modified Price-Earnings Growth (PEG) Model by Easton (2004)

$$P_t = \frac{FEPS_{t+1} + R_{EAST} \times k \times FEPS_{t+1} - FEPS_{t+2}}{R_{EAST}^2} \quad \text{(A.1)}$$

R_{EAST}= cost of equity capital.

We use a numerical binary search to equate the right-hand side to the left-hand side of equation A.1 within a difference of $0.001.

2. Gode and Mohanram (2003)

$$R_{GM} = A + \sqrt{A^2 + \left(\frac{FEPS_{t+1}}{P_t}\right) \times (g_2 - g)} \quad \text{(A.2)}$$

$$A = \frac{1}{2} \times \left(g + \frac{k \times FEPS_{t+1}}{P_t} \right)$$

$$g_2 = \frac{(FEPS_{t+2} - FEPS_{t+1})}{FEPS_{t+1}}$$

$$g = rf - 0.03$$

R_{GM}= cost of equity capital.

Here, growth rate (g) is calculated using the contemporaneous risk-free rate (rf is the yield on 10-year Treasury bonds) minus 3 percent.

3. Claus and Thomas (2001)

$$P_t = BV_t + \sum_{i=1}^{6} \frac{FEPS_{t+i} - R_{CT} \times BV_{t+i-1}}{(1+R_{CT})^i} + \frac{(FEPS_{t+6} - R_{CT} \times BV_{t+5}) \times (1+g)}{(R_{CT} - g) \times (1+R_{CT})^5} \quad \text{(A.3)}$$

R_{CT}= cost of equity capital.

We use a numerical binary search to equate the right hand side to the left hand side of equation A.3 within a difference of $0.001.

4. Gebhardt *et al*. (2001)

$$P_t = BV_t + \frac{(FROE_{t+1} - R_{GLS}) \times BV_t}{(1+R_{GLS})} + \frac{(FROE_{t+2} - R_{GLS}) \times BV_{t+1}}{(1+R_{GLS})^2} + TV \quad \text{(A.4)}$$

$$TV = \sum_{i=3}^{T-1} \frac{(FROE_{t+i} - R_{GLS}) \times BV_{t+i-1}}{(1+R_{GLS})^i} + \frac{(FROE_{t+T} - R_{GLS}) \times BV_{t+T-1}}{R_{GLS} \times (1+R_{GLS})^{T-1}}$$

FROE is calculated as income available to shareholders scaled by the lagged total book value of

equity. From the 3rd year to the *T*th year, *FROE* is assumed to decline linearly to an equilibrium return on equity (*ROE*). The equilibrium return on equity is determined by a historical 10-year industry median *ROE*. We use Fama and French (1997) to classify 48 industries. If the industry *ROE* is less than the risk-free rate, we set the industry ROE to be the risk-free rate.
R_{GLS}= cost of equity capital.

We use a numerical binary search to equate the right-hand side to the left-hand side of equation A.4 within a difference of \$0.001.

Appendix B

CEO Compensation Portfolio *Delta* and *Vega* Measures

Data used to construct management price and volatility sensitivity come from multiple sources. More specifically, we obtain management compensation and ownership data from the S&P ExecuComp database. Financial information is from Compustat annual files and stock return information is from CRSP monthly files. Yields on long-term government bonds are obtained from the Federal Reserve Bank.

The theoretical framework used to construct management compensation sensitivities to stock price and stock return volatility originates from the Black-Scholes option pricing model adjusted for dividends. The model is presented as follows:

$$Call = Se^{-dT}N(Z) - Xe^{-rT}N\left(Z - \sigma\sqrt{T}\right) \tag{B.1}$$

with

$$Z = \frac{ln\left(\frac{S}{X}\right) + T\left(r - d + \frac{\sigma^2}{2}\right)}{\sigma\sqrt{T}}$$

where

N = cumulative probability function for the normal distribution

S = price of underlying stock

X = exercise price of the option

σ = expected stock return volatility of the underlying stock over the life of the option

r = risk-free interest rate

T = time to maturity of the option

d = expected dividend yield over the life of the option

Option *delta* is the partial derivative of the option price with respect to stock price and option *vega* is the partial derivative of the option price with respect to stock return volatility as follows:

$$\mathrm{Delta} = \mathrm{e}^{-\mathrm{dT}}\mathrm{N}(\mathrm{Z}) \tag{B.2}$$

$$\mathrm{Vega} = \mathrm{e}^{-\mathrm{dT}}\mathrm{N}'(\mathrm{Z})\mathrm{S}\sqrt{\mathrm{T}} \tag{B.3}$$

where

N′ = density function for the normal distribution

To capture option *delta* and *vega*, we use six variables, namely, stock price, dividend yield, stock return volatility, risk-free rate, exercise price and time to maturity. The variables are estimated following Core and Guay (2002):

Stock price

We use the closing price at the end of the fiscal year as the stock price. Stock price data are from Compustat annual files.

Dividend yield

Dividend yield is estimated as the firm's average dividend ratio over the preceding three years. Dividend ratio is the ratio of common dividend over the market value of equity. Dividend yield data are from the Compustat annual files.

Stock return volatility

Stock return volatility is defined as the annualized monthly volatility of stock returns over the preceding five years. Monthly stock return data are from CRSP monthly files.

Risk-free rate

We adopt the yield of 10-year US Treasury bonds as the proxy for the risk-free rate. Treasury yield data are from the Federal Reserve Bank.

Exercise price and time to maturity

We partition a CEO's option portfolio into three parts: new option grants, previous exercisable option grants and previous non-exercisable option grants. Full information about the exercise price and time to maturity is available from ExecuComp for new grants, which makes the calculation for new grants much easier. However, no data are available on the exercise price and time to maturity for previous option grants. We therefore rely on the approximation method developed by Core and Guay (2002).

To estimate the average exercise price for previous option grants, we divide the realizable value of the options by the number of options to find the average difference between stock price and exercise price. We then subtract the difference from the stock price to get the exercise price. For the time to maturity of previous option grants, we set the maturity of exercisable (non-exercisable) options as four (one) years less than that of new grants. If there are no new grants in the current year, we set the time to maturity of exercisable (non-exercisable) options to nine (six) years. Therefore, the maturity of exercisable options is always three years less than that of non-exercisable options.

We first estimate *delta* and *vega* for each type of option grant and then calculate the stock price and stock return volatility sensitivities of the management's option and stock holdings as follows:

$$Price\ Sensitivity\ =\ \frac{S}{100}(Delta_{NG} * N_{NG} + Delta_{PGEX} * N_{PGEX} + Delta_{PGUNEX} * N_{PGUNEX} + N_{STK}) \quad \text{(B.4)}$$

$$Volatility\ Sensitivity\ =\ \frac{1}{100}(Vega_{NG} * N_{NG} + Vega_{PGEX} * N_{PGEX} + Vega_{PGUNEX} * N_{PGUNEX}) \quad \text{(B.5)}$$

where *S* is the stock price and *N* is the number of options/stocks in thousands. The subscript *NG* stands for new option grants; the subscript *PGEX* stands for previous exercisable option grants; the subscript *PEUNEX* stands for previous non-exercisable option grants; and the subscript *STK* stands for stock holdings.

Table 1. Descriptive Statistics

Variable Name	Mean	Q_1	Q_3	Median	Std. Dev.
R_{AVE}	0.0948	0.0758	0.1063	0.0903	0.0339
R_{EAST}	0.1114	0.0790	0.1268	0.0989	0.0600
R_{GM}	0.0987	0.0793	0.1115	0.0957	0.0373
R_{CT}	0.0861	0.0647	0.1002	0.0818	0.0400
R_{GLS}	0.0843	0.0656	0.0992	0.0809	0.0305
BM	0.5928	0.1779	0.8842	0.4857	0.5123
LTG	0.1526	0.1095	0.1910	0.1446	0.8350
Disp	0.1247	0.0400	0.1300	0.0700	0.2593
Size	7.7202	6.6895	8.6790	7.6073	1.5258
Leverage	0.2103	0.0653	0.3183	0.1991	0.1669
B_{MKT}	0.9405	0.6475	1.0900	0.9778	0.5227
B_{SMB}	0.2085	0.0570	0.6001	0.1986	0.6786
B_{HML}	0.0581	0.0270	0.4008	0.1167	0.8043
CEOPRICESEN ($000)	719.727	49.384	388.373	139.842	6646.130
CEOVOLSEN ($000)	106.063	38.277	101.988	63.711	297.506

This table present descriptive statistics for variables used in this study. The sample comprises of 11,041 firm-year observations spanning the period 1992-2009 for which data to compute CEO compensation portfolio sensitivities and the implied cost of equity capital are available. The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2004), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *CEOPRICESEN* is the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *CEOVOLSEN* is the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns.

Table 2. The Relation between the Average Implied Cost of Equity Capital (R_{AVE}) and CEO Compensation Portfolio Sensitivities to Stock Price and Stock Return Volatility

Variable Name	Predicted Sign	Model 1	Model 2	Model 3	Model 4
Intercept	?	0.1243	0.1208	0.1169	0.1081
		(14.29)***	(13.39)***	(15.85)***	(14.07)***
LCEOPRICESEN	-	-0.0060	-0.0054	-0.0044	-0.0035
		(-5.23)***	(-6.89)***	(-3.91)***	(-4.14)***
LCEOVOLSEN	+	0.0016	0.0018	0.0012	0.0021
		(3.66)***	(4.38)***	(3.59)***	(4.14)***
BM	+			0.0099	0.0100
				(10.77)***	(9.17)***
LTG	+			0.0280	0.0739
				(1.75)*	(5.85)***
Disp	+			0.0206	0.0276
				(2.12)**	(2.35)**
Size	-			-0.0014	-0.0021
				(-2.96)***	(-3.27)***
Leverage	+			0.0236	0.02556
				(6.17)***	(7.11)***
B_{MKT}	+			0.0063	0.0040
				(3.62)***	(3.68)***
B_{SMB}	+			0.0014	0.0006
				(1.25)	(1.18)
B_{HML}	+			0.0020	0.0026
				(2.26)**	(4.15)***
Year Fixed Effect		No	Yes	No	Yes
Industry Fixed Effect		No	Yes	No	Yes
Adj. R^2		0.06	0.15	0.20	0.34
N		11,041	11,041	11,041	11,041

This table presents results from regression models of the average implied cost of equity capital to a set of control variables and sensitivities of CEO compensation portfolios to stock price and stock return volatility. The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2004), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *CEOPRICESEN* is the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *CEOVOLSEN* is the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

Table 3. The Relation between Individual Implied Cost of Equity Capital Measure and CEO Compensation Portfolio Sensitivities to Stock Price and Stock Volatility

Variable Name	Predicted Sign	R_{EAST}	R_{GM}	R_{CT}	R_{GLS}
Intercept	?	0.1505	0.1037	0.1164	0.0972
		(16.87)***	(11.25)***	(14.31)***	(20.23)***
LCEOPRICESEN	-	-0.0055	-0.0021	-0.0027	-0.0030
		(-6.77)***	(-5.49)***	(-3.66)***	(-4.74)***
LCEOVOLSEN	+	0.0026	0.0018	0.0025	0.0010
		(3.76)***	(5.15)***	(3.65)***	(2.23)**
BM	+	0.0096	0.0078	0.0058	0.0122
		(4.69)***	(7.71)***	(6.70)***	(9.78)***
LTG	+	0.0033	0.1054	0.0016	0.0001
		(4.87)***	(4.86)***	(1.41)	(0.30)
Disp	+	0.0788	0.0084	0.0069	0.0153
		(5.29)***	(2.65)**	(2.95)***	(2.97)**
Size	-	-0.0066	-0.0015	-0.0029	-0.0008
		(-4.89)***	(-2.17)**	(-4.20)***	(-2.12)**
Leverage	+	0.0392	0.0105	0.0175	0.0270
		(6.34)***	(6.01)***	(4.88)***	(4.95)***
B_{MKT}	+	0.0178	0.0011	0.0054	0.0056
		(5.78)***	(0.74)	(2.94)***	(3.78)***
B_{SMB}	+	0.0057	0.0007	0.0009	0.0022
		(3.04)***	(0.03)	(0.73)	(2.38)**
B_{HML}	+	-0.0003	0.0013	0.0012	0.0031
		(-0.22)	(2.05)**	(1.47)	(2.73)***
Year Fixed Effect		Yes	Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes	Yes
Adj. R^2		0.32	0.21	0.20	0.34
N		11,041	11,041	11,041	11,041

This table presents results from regression models of individual implied cost of equity capital to a set of control variables and sensitivities of CEO compensation portfolios to stock price and stock return volatility. R_{EAST} is from Easton (2002), R_{GM} is from Gode and Mohanram (2003), R_{CT} is from Claus and Thomas (2001), and R_{GLS} is from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *LCEOPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *LCEOVOLSEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

Table 4. The Relation between Annual Change in the Average Cost of Equity Capital (ΔR_{AVE}) and Annual Change in CEO Compensation Portfolio Sensitivities to Stock Price and Stock Return Volatility

Variable Name	Predicted Sign	Model 1	Model 2	Model 3	Model 4
Intercept	?	0.0046	0.0170	0.0045	0.0131
		(1.36)	(1.48)	(1.39)	(1.47)
ΔLCEOPRICESEN	-	-0.0233	-0.0134	-0.0239	-0.0146
		(-4.82)***	(-6.67)***	(-5.20)***	(-4.28)***
ΔLCEOVOLSEN	+	0.0057	0.0044	0.0056	0.0045
		(4.05)***	(3.90)***	(3.79)***	(4.02)***
ΔBM	+			0.0026	0.0052
				(1.09)	(2.17)**
ΔLTG	+			0.0339	0.069
				(1.73)*	(2.05)**
ΔDisp	+			0.0069	0.0171
				(0.93)	(1.35)
ΔSize	-			-0.0014	-0.0021
				(-2.36)**	(-2.27)**
ΔLeverage	+			0.0098	0.00175
				(1.49)	(1.11)
ΔB_{MKT}	+			0.0053	0.0021
				(1.41)	(1.40)
ΔB_{SMB}	+			0.0032	0.0006
				(1.20)	(0.64)
ΔB_{HML}	+			0.0017	0.0011
				(1.67)*	(1.37)
Year Fixed Effect		No	Yes	No	Yes
Industry Fixed Effect		No	Yes	No	Yes
Adj. R^2		0.14	0.16	0.15	0.21
N		9,293	9,293	9,293	9,293

This table presents results from regression models of annual change in the average implied cost of equity capital to a set of annual change in control variables and annual change in sensitivities of CEO compensation portfolios to stock price and stock return volatility. The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2002), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *LCEOPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *LCEOVOLSEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

Table 5. The Relation between Annual Change in the Individual Implied Cost of Equity Capital Measure and Annual Change in CEO Compensation Portfolio Sensitivities to Stock Price and Stock Return Volatility

Variable Name	Predicted Sign	ΔR_{EAST}	ΔR_{GM}	ΔR_{CT}	ΔR_{GLS}
Intercept	?	0.0148	0.0123	0.0169	0.0140
		(1.47)	(1.18)	(1.64)*	(1.16)
ΔLCEOPRICESEN	-	-0.0211	-0.0099	-0.0098	-0.0153
		(-7.11)***	(-3.59)***	(-3.49)***	(-6.64)***
ΔLCEOVOLSEN	+	0.0046	0.0034	0.0033	0.0049
		(3.19)***	(3.31)***	(3.32)***	(6.37)***
ΔBM	+	0.0052	0.0071	0.0021	0.0019
		(1.82)*	(3.47)***	(0.80)	(0.80)
ΔLTG	+	0.0018	0.0051	0.0041	0.0001
		(3.71)***	(1.68)*	(3.73)***	(0.44)
ΔDisp	+	0.0046	0.0160	-0.0020	0.0062
		(1.86)*	(1.78)*	(-0.22)	(1.55)
ΔSize	-	-0.0056	-0.0042	-0.0011	-0.0011
		(-2.29)**	(-1.93)**	(-0.21)	(-2.03)**
ΔLeverage	+	0.0235	0.0054	0.0068	0.0133
		(2.19)**	(0.48)	(0.80)	(2.47)**
ΔB_{MKT}	+	0.0074	0.0048	0.0028	-0.0003
		(1.28)	(1.30)	(0.52)	(-0.15)
ΔB_{SMB}	+	0.0049	0.0029	-0.0019	-0.0004
		(1.26)	(1.07)	(-0.60)	(-0.24)
ΔB_{HML}	+	0.0026	0.0029	0.0008	0.0013
		(1.92)**	(2.02)**	(0.51)	(2.28)**
Year Fixed Effect		Yes	Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes	Yes
Adj. R^2		0.14	0.14	0.12	0.21
N		9,293	9,293	9,293	9,293

This table presents results from regression models of annual change in individual implied cost of equity capital to a set of annual change in control variables and annual change in sensitivities of CEO compensation portfolios to stock price and stock return volatility. R_{EAST} is from Easton (2002), R_{GM} is from Gode and Mohanram (2003), R_{CT} is from Claus and Thomas (2001), and R_{GLS} is from Gebhardt *et al*. (2001). BM is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *LCEOPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *LCEOVOLSEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

TABLE 6. The Relation between Implied Cost of Equity Capital and the Ratio of CEO Compensation Portfolio Sensitivities

Variable Name	Predicted Sign	R_{AVE}	R_{EAST}	R_{GM}	R_{CT}	R_{GLS}
Intercept	?	0.0976	0.1338	0.0963	0.1066	0.0977
		(16.85)***	(18.52)***	(13.28)***	(16.81)***	(24.48)***
CEOSENRATIO	-	0.0086	0.0135	0.0079	0.0101	0.0055
		(4.10)***	(3.95)***	(2.55)**	(3.39)***	(3.26)***
BM	+	0.0098	0.0092	0.0077	0.0073	0.0121
		(9.45)***	(4.31)***	(7.70)***	(6.19)***	(8.99)***
LTG	+	0.0240	0.0012	0.0418	0.0015	0.0002
		(1.60)*	(0.88)	(1.80)*	(1.39)	(0.63)
Disp	+	0.0206	0.0579	0.0053	0.0054	0.0151
		(2.20)**	(2.21)**	(1.53)	(1.64)*	(2.83)***
Size	-	-0.0033	-0.0079	-0.0013	-0.0033	-0.0020
		(-5.35)***	(-6.52)***	(-2.01)**	(-4.51)***	(-3.51)***
Leverage	+	0.0241	0.0401	0.0107	0.0192	0.0230
		(5.86)***	(6.04)***	(2.99)***	(3.78)***	(4.84)***
B_{MKT}	+	0.0062	0.0174	0.0011	0.0052	0.0054
		(3.66)***	(5.85)***	(0.70)	(2.99)***	(3.81)***
B_{SMB}	+	0.0009	0.0046	0.0002	0.0004	0.0018
		(0.88)	(2.74)***	(0.24)	(0.35)	(2.23)**
B_{HML}	+	0.0025	0.0007	0.0015	0.0016	0.0034
		(2.66)***	(0.41)	(2.29)	(1.82)*	(2.91)***
Year Fixed Effect		Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes	Yes	Yes
Adj. R^2		0.33	0.32	0.20	0.18	0.37
N		11,041	11,041	11,041	11,041	11,041

This table presents results from regression models of implied cost of equity capital to a set of control variables and the ratio of the sensitivity of CEO option portfolio to stock volatility over the sensitivity of CEO option and stock portfolio to stock price (*CEOSENRATIO*). The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2002), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

TABLE 7. The Relation between the Average Implied Cost of Equity Capital (R_{AVE}) and Alternative Measures of Compensation Portfolio Sensitivities to Stock Price and Stock Return Volatility

Variable Name	Predicted Sign	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	?	0.1162 (17.81)***	0.09871 (17.78)***	0.1043 (16.93)***	0.1041 (18.59)***	0.1017 (19.45)***	0.1037 (19.96)***
LMGMPRICESEN	-	-0.0047 (-3.73)***					
LMGMVOLSEN	+	0.0028 (3.70)***					
MGMSENRATIO	+		0.0162 (3.82)***				
LCEOPRICESEN_STOCK	-			-0.0007 (-1.77)*	-0.0007 (-1.74)*	-0.0010 (-2.29)**	-0.0008 (-2.19)**
LCEOPRICESEN_OPTION	-			-0.0048 (-3.67)***			
LCEOVOLSEN	+			0.0041 (3.45)***			
LCEOPRICESEN_EXOPTION	-				-0.0032 (-3.21)***		-0.0025 (-3.19)***
LCEOVOLSEN_EXOPTION	+				0.0019 (2.93)***		0.0017 (2.81)***
LCEOPRICESEN_NONEXOPTION	-					-0.0057 (-3.52)***	-0.0036 (-3.29)***
LCEOVOLSEN_NONEXOPTION	+					0.0052 (3.98)***	0.0040 (3.34)***
Control Variables Included		Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect		Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2		0.35	0.34	0.34	0.34	0.34	0.36
N		11,041	11,041	11,041	11,041	11,041	11,041

This table presents results from regression models of implied cost of equity capital to a set of control variables and alternative measures of compensation portfolio to stock price and stock return volatility. The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2002), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *BM* is the ratio of the book value over the market value of equity; *LTG* is the analyst long-term growth in earnings forecast from I/B/E/S; *Disp* is the forecast dispersion defined as the coefficient of variation of I/B/E/S earnings forecasts; *Size* is the natural logarithm of the market value of equity (in millions); *Leverage* is the ratio of long-term debt over total assets; B_{MKT}, B_{SMB}, and B_{HML} are factor loadings from the Fama and French (1996) three-factor model on risk factors. *LMGMPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the top five managers' stock options plus the change in their common stockholdings for a 1 percent change in the value of the firm's stock price.

LMGMVOLSEN is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the top five managers' option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. *MGMSENRATIO* is the ratio of *LMGMVOLSEN* over *LMGMPRICESEN*. *LNCEOPRICESEN_STOCK* is the natural logarithm of the change in the CEO's stock portfolio for a 1 percent change in the value of the firm's stock price. *LNCEOPRICESEN_OPTION* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options for a 1 percent change in the value of the firm's stock price. *LNCEOPRICESEN_EXOPTION* (*LNCEOPRICESEN_NONEXOPTION*) is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's exercisable (non-exercisable) stock options for a 1 percent change in the value of the firm's stock price. *LNCEOVOLSEN_EXOPTION* (*LNCEOVOLSEN_NONEXOPTION*) is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's exercisable (non-exercisable) stock options for a 0.01 change in the annualized standard deviation of the firm's stock returns. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

Table 8. Robustness Tests of Endogeneity on the Relation between the Average Implied Cost of Equity Capital (R_{AVE}) and CEO Compensation Portfolio Sensitivities to Stock Price and Stock Volatility

Variable Name	Predicted Sign	Model 1 *Regression with Lagged R_{AVE}*	Model 2 *Regression with Lagged Sensitivities*	Model 3 *Two-stage Least Squares (2 SLS) Regression*
Intercept	?	0.0579 (6.34)***	0.1086 (11.25)***	0.1082 (14.31)***
LCEOPRICESEN	-	-0.0025 (-5.23)***		
LCEOVOLSEN	+	0.0018 (3.89)***		
LCEOPRICESEN $_{t-1}$	-		-0.0020 (-3.42)***	
LCEOVOLSEN $_{t-1}$	+		0.0018 (2.78)***	
Pr(LCEOPRICESEN)	-			-0.0024 (-3.92)***
Pr(LCEOVOLSEN)	+			0.0020 (2.61)***
$R_{AVE\ t-1}$	+	0.4466 (5.29)***		
Control Variables Included		Yes	Yes	Yes
Year Fixed Effect		Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes
Adj. R^2		0.51	0.34	0.34
N		9,293	9,293	8,471

This table presents results from various robustness tests of endogeneity on the relation between CEO compensation portfolio sensitivities and the average implied cost of equity capital. The average implied cost of equity capital (R_{AVE}) is the equally-weighted average of the four implied cost of equity measures: R_{EAST} from Easton (2002), R_{GM} from Gode and Mohanram (2003), R_{CT} from Claus and Thomas (2001), and R_{GLS} from Gebhardt *et al*. (2001). *LCEOPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *LCEOVOLSEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. *Pr(LCEOPRICESEN)* and *Pr(LCEOVOLSEN)* are the predicted values of CEO compensation portfolio sensitivities from the first-stage regression. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.

Table 9. SEO Underpricing and CEO Compensation Portfolio Sensitivities to Stock Price and Stock Return Volatility

Variable Name	Predicted Sign	Model 1	Model 2	Model 3	Model 4
Intercept	?	0.0537	0.0655	0.0208	0.0266
		(6.12)***	(4.18)***	(5.35)***	(3.56)***
LCEOPRICESEN	-	-0.0058	-0.0079	-0.0037	-0.0051
		(-3.17)***	(-3.97)***	(-3.12)***	(-3.63)***
LCEOVOLSEN	+	0.0013	0.0011	0.0011	0.0010
		(0.91)	(0.90)	(0.87)	(0.71)
Size	-			-0.0009	-0.0010
				(-0.67)	(-1.11)
#N_Analyst	-			-0.0038	-0.0042
				(-3.23)***	(-3.37)***
Idio_Vol	+			0.3471	0.4423
				(4.25)***	(3.47)***
Relative_Offer_Size	+			0.0321	0.0429
				(2.77)***	(2.66)***
CAR_Positive	?			0.0091	0.0086
				(1.55)	(1.12)
CAR_Negative	+			0.0247	0.0288
				(1.88)*	(2.01)**
Tick[0,0.25]	+			0.0006	0.0005
				(0.45)	(0.23)
Price	-			-0.0054	-0.0067
				(-3.11)***	(-3.44)***
NYSE	-			-0.0001	-0.0001
				(-0.17)	(-0.16)
Year Fixed Effect		No	Yes	No	Yes
Industry Fixed Effect		No	Yes	No	Yes
Adj. R^2		0.02	0.16	0.12	0.19
N		1,112	1,112	1,112	1,112

This table presents results from regression models of SEO underpricing on a set of control variables and CEO compensation portfolio sensitivities to stock price and stock return volatility. SEO underpricing is the return from the closing price on the day immediately before the offer date to the offer price. *LCEOPRICESEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's stock options plus the change in the CEO's common stockholdings for a 1 percent change in the value of the firm's stock price. *LCEOVOLSEN* is the natural logarithm of the change in the dividend-adjusted Black-Scholes value of the CEO's option portfolio for a 0.01 change in the annualized standard deviation of the firm's stock returns. Firm size (*Size*) is the natural log of the market value of equity at the end of the year before the SEOs; number of analysts *(#N_Analyst*) is the number of analysts covering the firms in the year before the SEO; idiosyncratic volatility (*Idio_Vol*) is the natural log of the standard deviation of the residuals from the regression of monthly returns on Fama and French (1996) risk factors in the five years before the SEOs; relative offer size (*Relative_Offer_Size*) is the offer size relative to outstanding shares; positive pre-offer abnormal return (*CAR_Positive*) is the cumulative abnormal return in the 10 days leading to the offer date if this is a positive value; negative pre-offer abnormal return (*CAR_Negative*) is the cumulative abnormal return in the 10 days leading to the offer date if this is a negative value; *Tick[0,0.25]* is the rounding of the offer price to a $0.25 increment; stock price (*Price*) is the stock price 10 days prior to the offer date, and NYSE is a dummy variable for NYSE stocks. Industry fixed effect is defined by the Fama and French (1997) industry classifications. Two-way clustered *t*-statistics are based on standard errors clustered by firm and year. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level.