EXECUTIVE COMPENSATION, BANKRUPTCY RISK, AND MANAGERIAL RISK TAKING

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Abstract

Compensation studies suggest that equity-based compensation can align the interests of shareholders and managers in terms of managerial risk taking choices. This study extends the literature by examining whether equity-based compensation is used to incorporate the interests of bondholders with those of managers and shareholders in terms of managerial risk taking. In particular, it hypothesizes that equity-based compensation induced managerial risk taking is different for firms with and without high bankruptcy risk. Samples are partitioned according to measure of ex ante bankruptcy risk. The results show that the sensitivity of CEO wealth to stock returns volatility (Vega) has a lower impact on managerial risk taking for firms with higher bankruptcy risk than those with lower bankruptcy risk, while the sensitivity of CEO wealth to stock price (Delta) has a higher impact on managerial risk taking for firms with higher bankruptcy risk than those with lower bankruptcy risk, even after controlling for the effects of firm's size, firm's cash flow, and firm's investment opportunities.

Keywords: Executive Compensation, Stock Options, Vega, Delta, Risk shifting, Investment Policy

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1. Introduction

This study provides empirical evidence on whether equity-based compensation is used to incorporate the interests of bondholders with those of managers and shareholders in terms of managerial risk taking. There is an extensive literature on executive compensation aligning interests between shareholders and managers in the risk-related incentive problem. Managers are typically assumed to be more risk-averse than shareholders due to human capital risks as well as less diversified wealth portfolio. Managers take actions that affect the risk of the outcome of the project. They may choose to avoid risk-increasing positive net present value (NPV) projects that benefit shareholders. Prior theoretical studies have demonstrated that this conflict can be solved using different compensation forms based on alternative performance measures. Specifically, to induce effort, managers are provided with incentive compensation that is tied to performance. This, however, increases the riskiness of managers' compensation and creates an incentive for risk-averse managers to reduce firm risk. Executive stock option (ESO) provides risk-averse managers with incentives to increase firm risks by introducing convexity into compensation contract and protecting the downside loss of managers (Haugen and Senbet (1981) and Smith and Stulz (1985)). By contrast, awarding stock holdings, given its linear payoff structure, creates incentive for risk-averse managers to take actions that reduce firm risk. Some recent theoretical work suggests that the general wisdom that ESO increase manager's risk taking may not be true for all circumstances. The effect will greatly depend on the managerial utility function and risk aversion. Under some circumstances, ESO may instead discourage manager's risk taking behavior (Ross (2004)).

In addition, there is an extensive literature on shareholder-bondholder conflict. Black and Scholes (1973) point out that equity in a levered firm can be viewed as a call option on the firm, having a strike price equal to the face value of the outstanding debt. Since the value of call options increases with the variance of the underlying asset, the value of equity increases with the firm's risk. For firms with risky debt, Jensen and Meckling (1976) argue that shareholders have incentives to invest in high risk negative net present value (NPV) projects at the expense of bondholders. Since shareholders have limited liabilities when the firm does not perform well, they may prefer to shift to high risk negative NPV project when the firm is in high bankruptcy risk, believing that they are playing with other people's money.1 This is referred to as risk shifting (asset substitution) problem, i.e., shareholders have incentives to increase firm's risk once debt has been put in place. If managers' interests are fully aligned with shareholders', then managers too may want to invest in risky projects even if they have negative NPV.

Previous theoretical models suggest that the compensation contract can be designed to reduce managerial risk shifting problem when debt is in place. Leland and Pyle (1977) and Choe (2003) predict a theoretical positive relationship between debt and equity compensation. On the other hand, John and John (1993) predict a theoretical negative relation between debt and equity compensation. Harikumar (1996) shows that option based compensation should be increased to eliminate risk-shifting incentives. Garvey and Mawani (2005) argue that stock option plans can reduce the risk shifting problem because managers are far more leveraged than shareholders due to the exercise price of options.

Previous empirical studies have shown that the design of the compensation contract is affected by firm's bankruptcy risk (Gilson and Vetsuypens (1993), Hayes and Hillegeist (2006), and Ortiz-Molina (2007)). 2 There is limited evidence, however, of the manager's risk taking under bankruptcy risk and how they are affected by the structure of the compensation contract. Does bankruptcy risk affect the relation of equity-based compensation and managerial risk taking decisions? Does equity-based compensation exacerbate or mitigate managerial risk taking for firms that are predicted to have a high bankruptcy risk?

This study tests empirically whether the relation between equity-based compensation and managerial risk taking differs for firms with and without high bankruptcy risk. The hypothesis posits that equity-based compensation either aggravates or mitigates risk shifting for high bankruptcy risk firms relative to low & median bankruptcy risk firms. The samples are obtained from Compustat Execucomp firms over the period 1992-2004, with financial and returns data obtained from Compustat Industrial Annual and CRSP, respectively. Following Core and Guay (2002a), Rajgopal and Shevlin (2002), Knopf et al. (2002) and Coles et al. (2006), equity compensation incentives are measured using Vega and Delta. Vega is defined as the sensitivity of the CEO's option portfolio value to a 1% change in the underlying stock return volatility, where the option value is the Black-Scholes value of a European call option as adjusted for dividends by Merton (1973). Delta is defined as the change in total CEO's wealth based on stock and option ownership from a 1% change in stock price. The managerial risk-taking choice is proxied using firm's research and development (R&D) investment.3 Firms are classified as high bankruptcy risk firms if it falls in the top deciles firms (deciles 8 – 10 based on all Compustat firms) based on Zmijewski (1984)'s financial condition (ZFC) score.4

This study recognizes the potential endogeneity and simultaneity problems in empirical tests utilizing equity compensation and managerial risk taking consequences. On the one hand, the compensation committee sets CEO incentive compensation based on the firms' expected future risks. On the other hand, CEO makes risk-taking decisions based on the incentives created by their compensation contract. Following previous studies, a simultaneous equations model (SEM) is used to model risky investments as influenced by equity incentive compensations and vice versa.

The results of this study show that compensation affects managerial risk taking differently for high bankruptcy risk firms versus low bankruptcy risk firms. In particular, it documents that, on average, CEO's managerial risk taking incentive as captured by Vega has a positive impact on managerial risk taking. However, this effect is lower for high bankruptcy risk firms versus low bankruptcy risk firms. On the other hand, Delta has a higher impact on managerial risk choice for high bankruptcy risk firms versus low bankruptcy risk firms. The results hold after controlling for alternative specifications. Thus, the evidence suggests that compensation contracts may incorporate anticipated reactions of bondholders as well as of managers in terms of managerial risk taking choices.

This paper makes the following contributions to the literature. First, previous empirical research on managerial incentives and managerial risk taking mainly examines the ability of ESO to align manager and shareholder interests, namely, encourage managers to invest in risky projects. This study extends the literature by examining the relation between executive compensation and managerial risk

[1] Eisdorfer (2008) provides empirical evidence on the risk-shifting behavior in the investment decisions of financial distress firms using real options framework.

[2] These papers find conflicting results. For financially distressed firms, Gilson and Vetsuypens (1993) find that bankrupt companies increasingly switch to stock options as a compensation method in the years surrounding the bankruptcy or restructuring event. On the other hand, Hayes and Hillegeist (2006) find that the equity compensation to risk sensitivity for newly hired external CEOs is lower for firms with high financial distress risk than for firms with low financial distress risk for the period between 1992-2002. Ortiz-Molina (2007) finds that CEO compensation is related to firms' capital structure. Equity compensation to price sensitivity decreases in straight-debt leverage, but is higher in firms with convertible debt.

[3] Previous studies find that, as one of the firm's long-term investments, R&D investment is considered riskier than other types of long-term investments such as firm's capital expenditure, advertisement, and intercompany investments. Firm's R&D investment rather than firm's volatility is used because the former measures the actual behavioral of managers.

[4] We perform robustness tests using alternative measures for bankruptcy risk such as Ohlson (1980)'s *O-score, Altman's (1968) Z-score,* Begley *et al.* (1996) updated Z score, and S&P credit ratings. The main results are not changed.

taking behavior when managers face risk shifting problem in high bankruptcy risk.

Second, prior empirical research that examines executive compensation and the risk shifting problem generally focuses on the design of the compensation contract under bankruptcy risk. The current paper extends the literature by providing evidence on how managerial risk taking behavior is affected by the structure of the compensation contract for firms with and without high bankruptcy risk.

The rest of the paper is organized as follows. Section 2 discusses the previous related work and develops the hypotheses. Section 3 describes the samples, empirical methodology, and descriptive statistics, and Section 4 presents the empirical results. Section 5 provides robustness tests, and Section 6 concludes the paper.

2. Prior Literature and Hypotheses Development

The current paper is related to two lines of research, first, executive compensation and managerial risk taking in general, and second, executive compensation and risk shifting problems.

2.1 Equity compensation and managerial risk taking literature

There has been extensive literature examining the impact of managerial incentives on firms' risk taking. Earlier studies find conflicting results of equity-based compensation impact on firms' risk. For example, Larcker (1983) finds that corporate capital investment increases subsequent to a long-term performance plan adoption. On the other hand, the results of Gaver and Gaver (1993b) using 204 firms that adopted performance plans between 1971 and 1980 with matching samples provide little evidence that capital spending increases following adoption, and a significant decrease in average systematic risk (asset beta) following adoption. Defusco et al. (1990) find that after acceptance of ESO plan there is increased managerial risk taking as measured by implicit share price variance computed from Black-Scholes model, stock return variance, and ROA variance. The authors also find that ESO plan drives negative bond market reactions and positive stock market reactions. However, additional evidence by Defusco et al. (1991) shows that investment in R&D intensity declined significantly subsequent to ESO plan adoption while perquisite consumption, measured by SG&A, increased significantly.

Using Vega, the sensitivity of equity compensation to stock price volatility, to measure the managerial risk incentive, Rajgopal and Shevlin (2002) find that Vega is significantly positively related to the future level of exploration risk taken by the firm. Coles et al. (2006) examine the causal relation among CEO Vega and riskier investment policy, riskier financing policy, and higher volatility of stock returns for the period 1992-2002. Using simultaneous equations and three-stage-least-squares (3SLS) method, they find that higher Vega leads to higher R&D expenditure, lower capital expenditures, increased firm focus, higher leverage, and higher stock return volatility. In addition, Delta decreases with R&D expenditures, firm focus, leverage, and stock return volatility, and increases with capital expenditures.

Recent studies address whether equity-based compensation induced managerial risk taking will be different for firms with different characteristics. For example, Williams and Rao (2006) find CEOs of small firms are more likely to respond to stock option risk incentives than are CEOs of larger firms. Ghosh et al. (2007) find that increasing managerial ownership increases R&D at low ownership levels but not at high ownership levels. They also find that increasing option holdings tend to increase R&D investments, but the relationship is significant only at high levels of option holdings. On the other hand, they find that capital expenditures do not vary with the stock ownership and option holdings. Belkhir and Chazi (2010) find that compensation Vega increases risk-increasing investments, but only to a certain level. In particular, the coefficient on (Vega)2 is significantly negative, which suggests that once Vega becomes sufficiently high, the effect of Vega on risk becomes negative.

2.2 Risk shifting problem and equity-based compensation

Earlier studies that examine managerial risk shifting behavior mainly focus on specific industries. For example, Esty (1997) finds that a firm increases investment in risky assets after a conversion from mutual to stock ownership. Chevalier and Ellison (1997) find that during the fourth quarter the behind-market mutual funds have an incentive to increase their risks whereas funds that are ahead of the market have an incentive to lock in their gains. However, this situation reverses at the extreme positions. Funds might want to reduce their risks if their performance was extremely poor, and increase risks if performance was well ahead of the market. More recently, Eisdorfer (2008) provides evidence on the existence of risk-shifting behavior in the investment decisions of financial distress firms using real options framework. Under the real options framework, the value of delaying investment increases with uncertainty of the project's cash flow. Therefore, the current investment is expected to have a negative relation with volatility of the project's cash flows. However, when a firm is in high distress risk, investing in high risky project may increase shareholders' value because of the risk shifting problem. The author predicts that for financial distress risk firms, the positive effect of risk shifting dominates the negative effect of option to delay investment, and there is a weaker negative relation, or even a positive relation between investment and volatility. The empirical results support the hypothesis using data over the period 1963-2002, suggesting the existence of substantial risk-shifting behavior in financial distressed firms.

Previous theoretical study argues that compensation contract can be used to reduce the risk shifting problem of high bankruptcy risk firms (Brander and Poitevin (1992), John and John (1993), and Garvey and Mawani (2005)). Empirical studies have shown that compensation design is affected by risk shifting problem. For firms face bankruptcy risk, Gilson and Vetsuypens (1993, 1994) find a much stronger link between managers' wealth and firm performance, and a progressive switch to stock options as a compensation method in the years surrounding the bankruptcy or restructuring event. They also find that the creation of Delta in financially distressed firms is a direct consequence of high turnover in the top executive. New externally hired CEOs receive a large portion of their compensation in the form of stock options and restricted stock. Hayes and Hillegeist (2006) examine the relation between financial distress risk and initial CEO compensation contracts using 1,307 observations between 1992-2002. They find that new CEOs at firms with moderate to high bankruptcy risk receive between 15% and 36% less compensation (total direct and cash) compared to new CEOs at low-risk firms. For new CEOs whose firms face a substantial bankruptcy risk, Delta is lower. The authors also find that, on average, CEO' Vega/Delta is not related to the probability of bankruptcy. However, the interaction term of Vega/Delta ratio and outside new CEOs is greater for firms with low bankruptcy risk, suggesting that newly hired outside CEOs at firms with high bankruptcy risk are given weaker incentives to increase the standard deviation of firm returns.

Ortiz-Molina (2007) finds that leverage affects CEO Delta using data from 1993-1999. Using median regression and two-stage least absolute deviation estimator proposed by Amemiya (1982), the author finds that Delta decreases in firms with straight debt, but is higher in firms with convertible debt. In addition, as leverage increases, CEO Delta in options decreases faster than Delta in stock. Furthermore, CEO annual compensation is affected by leverage. The fraction of annual pay in options decreases in firms with straight debt, but increases in firms with convertible debt. These results are consistent with the hypothesis that firms trade-off shareholders and managers' incentive alignment in order to mitigate the conflict of interest between shareholders and bondholders.

Purnanandam (2008) develops a model that shows the optimal level of ex-post investment risk, from the shareholders' perspective, is determined by the tradeoff between the costs of financial distress and risk shifting problem. There exists a U-shaped relation between financial distress risk and risk management. A firm with high leverage has a higher incentive to engage in risk management. However, for firms with extremely high leverage, the risk management incentives disappear. The empirical tests using hedging data of 2,000 firms over 1996-1997 show that firms with higher leverage hedge more, although the hedging incentives disappear for firms with very high leverage.

2.3 Hypothesis Development

As stated above, managers are assumed more risk averse than shareholders, and prefer to take low-risk investment even with lower expected output, while shareholders prefer higher output regardless of risk. Output- (stock return-) based compensation, on the one hand, motivates managers to exert effort, but, on the other hand, makes managers' compensation riskier because of the linear payoff function causing managers' wealth to directly change with the performance of stock price. Options-based compensation provides managers with benefits from taking additional risk since the value of options increases in stock return volatility because of the convex payoff function.

For high bankruptcy risk firms, shareholders will act as playing with other person's money and may take on high-risk negative NPV project. Managers, when fully aligned with shareholders using stock compensation (i.e., Delta), will have the similar incentive to shareholders in terms of risk taking, namely, the risk shifting problem associated with risky debt, as argued in John and John (1993). Higher Delta is predicted to aggravate the risk shifting problem because it more strongly aligns manager interests with shareholder interests, thereby increasing managerial risk taking.

For managers with stock options compensation, there are two different predictions. First, John and John (1993) argue that managerial compensation in a levered firm can serve as a pre-commitment device to minimize risk shifting behavior. Their results show that higher equity compensation in contracts exacerbates the risk shifting problem associated with risky debt, which increases managerial risk seeking incentives. They suggest that reducing the alignment between managers and shareholders' interest mitigates managers' risk shifting behavior. Based on the above argument, stock option compensation may exacerbate the risk shifting problem.

On the other hand, Harikumar (1996) shows that the optimal manager-shareholders alignment that eliminates the risk-shifting incentive can be achieved using either stock or stock options as part of the compensation package. Specifically, consistent with John and John (1993), stock compensation is negatively related to debt level, and less stock compensation mitigates the risk-shifting incentive.

However, optimal option compensation is positively related to debt level. More option compensation mitigates the risk-shifting incentive while aligning manager-shareholders' interests.

Garvey and Mawani (2005) suggest that to overcome the risk shifting problem, shareholders can either provide managers with low Delta, or provide them with options with a carefully chosen exercise price. Options-based compensation provides managers "homemade leverage", which refers to the fact that compared to the shareholders' payoff function, managers that are given a certain number of stock options need to consider the combined payoffs to bondholders and the exercise price when making their decisions; while shareholders will only need to consider the payoffs to bondholders when making their decisions. Therefore, by adjusting the exercise price of options, managers of firms with different capital structures can effectively be provided the same risk taking incentives. The optimal option exercise price decreases as the firm's debt ratio increases. Firms with higher leverage can provide lower exercise price to managers and firms with lower leverage can provide higher exercise price to managers. Since managers can be far more leveraged than shareholders due to the exercise price of options, financial leverage will not increase manager's inclination to take on risk-increasing projects. Therefore, a leverage-induced risk shifting problem can be mitigated by granting options with a leverage-adjusted exercise price. Based on the above argument, options can be used to overcome the risk shifting problem when firm faces high probability of bankruptcy. Given these conflicting arguments, we do not predict the direction of managerial risk taking choices in response to Vega for firms with high bankruptcy risk.

Hypothesis 1A: Vega either aggravates or mitigates managerial risk taking for high bankruptcy risk firms than low and median bankruptcy risk firms.

Hypothesis 1B: Delta aggravates managerial risk taking for high bankruptcy risk firms than low and median bankruptcy risk firms.

3. Research Method

3.1 Sample

The sample is obtained from the Standard & Poor's Execucomp, Compustat industrial annual, and CRSP databases. We use the variables "BECAMECE" provided by Execucomp to identify CEOs of firms at the end of fiscal year from 1992 to 2004. We use this approach rather than the "CEOANN" flag provided by Execucomp, because the "CEOANN" identifies the individual who was CEO for the majority of the fiscal year, while we want to identify the CEO at the end of each year, so that we can examine the impact of beginning-of-year CEO incentives on his/her behavior in the following year.

We exclude firms in financial industries (SIC codes between 6000-6999) because these firms may have different investing and financing activities and managers may have different motivations on risk taking decisions. We also exclude firms with no long-term debt as these firms may not have significant conflicts of interest between shareholders and bondholders. In addition, we exclude firms with zero R&D investment, unless they happen to have had some positive R&D in the last two periods or future two periods. This is because of the concern that setting firms with missing R&D to zero makes it difficult to differentiate whether the zero R&D firm is actually no R&D investment or undisclosed R&D. Furthermore, for firms that do have zero R&D investment, it is hard to explain the impact of options-based compensation on the riskiness of investment. Finally, we exclude firms in industries with less than five firms with available data within each year. The final sample that includes all necessary data for the empirical analysis has 4,079 firm-year observations, representing 756 firms.

3.2. Construction of variables

3.2.1. Definition of high and low bankruptcy risk group

The debt-financed firms are categorized into high bankruptcy risk firms and other firms based on the decile rankings of Zmijewski's financial condition index (ZFC). Following Zmijewski (1984), Bamber et al. (1993), and Carcello and Neal (2003), the ZFC is calculated using the coefficients from Zmijewski (1984)'s Table 3:

ZFC = -4.336 –4.513 (net income /total assets) + 5.679 (total debt /total assets) + 0.004 (current assets /current liabilities)

In order to mitigate the survivorship bias, the bankruptcy risk deciles are determined based on all Compustat firms, including both active and inactive companies, for each year. This leads to unbalanced bankruptcy risk deciles in the sample. For example, the bankruptcy risk decile 10 (the highest bankruptcy risk decile) has only 40 firm-year observations, which is approximately 1% of the sample (43/4,079). We define the high bankruptcy risk indicator as 1 for observations in high bankruptcy risk deciles (deciles 8, 9 and 10), and 0 otherwise (for observations in the low and medium bankruptcy risk deciles). The high bankruptcy risk group includes 403 observations, and low to medium bankruptcy risk includes 3,676 observations. Defined in this way, the high bankruptcy risk is about 10 percent of all debt firms with the ZFC score available. This choice is reasonable since previous studies have shown that the risk shifting problem happens in severe bankruptcy risk firms, e.g., Hayes and Hillegeist (2006) and Purnanandam (2008).

3.2.2. Risky Investments

The dependent variable is measured using observable managerial investment decisions, R&D investment intensity, i.e., R&D expenditures scaled by the firm's average total assets. Following Coles et al. (2006), Ryan and Wiggins (2002), and Minton and Schrand (1999), we conduct tests for both investment level and industry-adjusted investment. The industry-adjusted R&D investment intensity is measured as firm-year R&D investment intensity adjusted by the median for all sample firms in the same two-digit SIC code for the same sample year. This measure controls for the differences across industries. Because of the industry adjustment, we eliminate firms in industries with less than five firms with available data.

3.2.3. Risk Taking Incentives

As pointed out in Core et al. (2003a), a key point in analyzing executive incentives is that the equity incentives are properly measured by portfolio incentives, i.e., the holdings of common stock, restricted stock, and stock options and not the grants for a given year. In addition, as argued in previous studies such as Guay (1999) and Knopf et al. (2002), there are two impacts of stock- and stock options-based compensation on managerial risk taking. First, the value of stock and options increase with stock price (the slope effect). There is a direct link between the payoffs of an option and the movements in the underlying stock price (Knopf et al. (2002)). This induces managers to invest in risk-increasing positive NPV project if the price effect is greater than zero. Second, the value of stock and options increase with firm volatility (the convexity effect) based on the option pricing theory. Therefore, when examining compensation incentive effects on firm's risk one should control Delta to examine Vega, and vice versa.

Following Guay (1999) and Core and Guay (2002a), CEO Vega is measured as the sensitivity of the CEO's option portfolio value to a 0.01 change in the underlying stock return volatility, where the option value is the Black-Scholes value of a European call option as adjusted for dividends by Merton (1973). The Black-Scholes option-pricing model adjusted for dividends is as follows:

$$c_t = S_t e^{-\delta(T-t)} N(d_1) - X e^{-r(T-t)} N(d_2)$$

where

$$d_1 = \frac{\ln(S_t / X) + (r - \delta + \sigma^2/2)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

and N(x) is the cumulative probability distribution function for a variable that is normally distributed with a mean of zero and a standard deviation of 1.0. St is the stock price at time t, X is the strike price, r is the continuously compounded risk-free rate, σ is the expected stock price volatility, δ is the expected dividend yield, T is the expiration date of the options, and T-t is the time to maturity of the option. The sensitivity of the change in option value to a 0.01 change in stock return volatility is calculated as:

$$PRS_t = [\partial w / \partial \sigma] * 0.01 = S * \exp(-\delta * (T-t)) * N'(d_1) * \sqrt{T-t} * 0.01$$

where N' is the normal density function, and other factors are defined as previously.

To empirical estimate Vega, the six inputs required are stock price (S), exercise price (X), time-to-maturity (T-t), expected stock-return volatility (σ), expected dividend yield (δ), and the risk-free rate (r). These variables are available for the current year granted options from Execucomp database. However, the exercise price and time-to-maturity are not available for previously granted options holdings.

For previously granted options, we use the Core and Guay (2002a) one-year approximation approach. Core and Guay (2002a) show that these proxies capture more than 99% of the variation in option portfolio value and sensitivities in a broad sample of actual and simulated CEO option portfolios. The one-year approximation approach uses the previous-year CEO unexercised exercisable and unexercisable options values as reported in the proxy statements to estimate the average exercise price of the previously granted options, and use the estimated average exercise price and the estimated time to maturity together with other available factors to estimate the incentives from previously granted options.

Delta is estimated as the change in total CEO wealth from a 1% change in stock price. Specifically, it is the sum of the change in the value of ESO slope incentives, the restricted stock holdings incentives, and the normal stock holdings incentives. (1) ESO slope incentives. It is the change in the value of CEO options holdings given a 1% change in stock price using dividend adjusted Black-Scholes methods. (2) Restricted stock holdings incentives. It is the change in the value of CEO restricted stock holdings given a 1% change in stock price. (3) Normal stock holdings incentives. It is the change in the value of CEO stock holdings given a 1% change in stock price. It is estimated by multiplying the market value of stock holdings at year-end t (indicated by the product of the number of shares owned by the CEO (SHROWN) and the stock price at fiscal year-end (PRCCF) by 1%.

Therefore,

Delta =∂w/∂S*price * 0.01 + RSTKHLDV*0.01 + SHROWN*PRCCF*0.01

3.3 Model and control variables

The empirical analysis uses simultaneous equations models (SEMs) to estimate the relation between executive compensation and managerial risk taking. SEMs are used because of the potential endogeneity problem: the compensation committee sets CEOs incentive compensation based on the firms' expected future risks; and CEOs make risk-taking decisions based on their incentives. Following Broussard et al. (2004) and Rajgopal and Shevlin (2002), we focus on the impact of Delta and Vega on subsequent risky investment. In this way, we are able to find the beginning of year CEO incentives on behavior in the following year. As a robustness check, we also perform the same regressions for contemporaneous incentive and investment.

The basic regression model can be specified as:

Risky Investmentt = f(LoDR X Vegat-1, LoDR X Deltat-1, HiDR, HiDR X Vegat-1, HiDR X Deltat-1, CONTROLt) (1)

Vegat-1 =f(Risky Investment t, Deltat-1, CONTROLt) (2)

Deltat-1 =f(Risky Investment t, Vegat-1, CONTROLt) (3)

where LoDR = 1 if the firms fall in the deciles 1-7 of the calculated Zmijewski (1984)'s ZFC score ranked based on all Compustat firms, and 0 otherwise. HiDR = 1 if the firms fall in the deciles 8-10 of the calculated Zmijewski (1984)'s ZFC score ranked based on all Compustat firms, and 0 otherwise. CONTROL is a vector of variables that are expected to influence a firm's risk taking, Vega, and Delta, respectively. By including the control variables, the effects of Vega and Delta on managerial risk taking are isolated.

The control variables are derived from previous studies on the determinants of R&D investments, Vega, and Delta, such as Guay (1999), Core and Guay (1999), Ryan and Wiggins (2002), and Coles et al. (2006). Control variables for the R&D investment equation include (1) Firm Size, defined as logarithm of sales. Smith and Watts (1992) predict that the larger the firm size, the greater the diversification, and consequently the lower the return variance. This leads to a negative relation between firm size and firm risk. Clinch (1991) documents that firm size and R&D are negatively related. Guay (1999), Coles et al. (2006), and Williams and Rao (2006) find that firm size has a significant negative impact on firm risk. Based on the results in these previous studies, we expect a negative relation between firm size and risky investments. (2) Investment Opportunity Set (IOS). In a perfect world, with frictionless capital markets, according to the Modigliani and Miller (1958) proposition, a firm's investment should depend only on the profitability of its investment opportunity sets. Firms with higher investment opportunities undertake higher level of risky investment to maintain their future growth. Guay (1999) and Hanlon et al. (2004) find that investment opportunity sets are positively related to firm risk as measured by stock return volatility after controlling for other factors. We expect a positive association between risky investment and IOS. IOS is proxied by market to book ratio, i.e., market value of equity plus the book value of total assets less book value of common equity, divided by book value of total assets. (3) Surplus Cash. A large literature examines the influence of financial constraints on investment, such as Fazzari, Hubbard, and Petersen (1988), Hoshi, Kashyap, and Scharfstein (1991) and Petersen and Rajan (1994). They find that cash flows and liquidity measures are strongly related to investment. Coles et al. (2006) find that surplus cash is significantly positively related to R&D investment. Following prior studies, we expect the level of risky investment to be positively related to surplus cash. Surplus Cash is measured as net cash flow from operating activities less maintenance investment expenditure plus research and development expenditure plus advertising expense, divided by beginning of year book value. The maintenance investment expenditure is measured as amortization and depreciation. (4) Firm risk. Parrino et al. (2005) find that a low risk firm suffers a higher overinvestment problem than a firm with high risk. Huang (2005) finds that for firms with low (high) earnings volatility, the value of CEO option holdings is significantly positively (negatively) correlated with ex post managerial risk-taking outcome. Therefore, we expect that firm risky investment is positively related to CEO Vega only for low risk firms.

Studies on determinants of CEO equity-based incentive compensation tends to explain whether firms grant stock options in accordance with theories of financial contracting and agency cost reduction. Following previous studies, the control variables for CEO Vega equation includes firm size, market to book, surplus cash, firm risk, CEO cash compensation, leadership duality, interlock relationship, Corporate Governance index (the G-index compiled by Gompers et al. (2003)), industry and year dummies. The control variables for CEO Delta equation includes firm size, market to book, surplus cash, firm risk, CEO tenure, leadership duality, interlock relationship, G-index, industry and year dummies. (1) Firm size is included to control for the probability of having a formal incentive compensation plan and the level and incentive sensitivity of compensation. Some previous studies argue that large firms may have greater equity compensation because (a) larger firms have higher agency costs and are harder to monitor, (b) large firms are more willing to incur the fixed administration costs of implementing sophisticated compensation plan, and (c) large firms are likely to employ more talented managers and tend to provide them with larger pay packages (e.g., Demsetz and Lehn (1985), Smith and Watts (1992) and Yermack (1995)). Smith and Watts (1992) find that firm size and the use of incentive compensation plans are positively related. Rajgopal and Shevlin (2002) and Coles et al. (2006) find that firm size is positively related to Vega. It is predicted that firm size is positively related to Vega and Delta. (2) Investment Opportunity Set. Several empirical studies examine the relation between the investment opportunity sets and executive compensation policies, including Clinch (1991), Smith and Watts (1992), Bizjak et al. (1993), Gaver and Gaver (1993a, 1995), Skinner (1993), Baber et al. (1996), and Guay (1999), etc. Smith and Watts (1992) and Gaver and Gaver (1993a) argue that growth firms are harder to monitor relative to firms with more asset in place, and more likely to use incentives compensation schemes. They provide evidence that firms with growth opportunities are less likely to use accounting-based bonus plans and more likely to use stock-option plans. Guay (1999) finds that cross-sectionally the Vega is positively related to firm's investment opportunities as measured by book to market ratio, R&D expenditure, and investment expenditure (the sum of capital expenditure plus acquisitions). This variable is predicted to have a positive relation with Vega and Delta. (3) Surplus cash. Previous studies argue that firms under cash constraints may use greater equity grants to substitute cash compensation in CEO's pay packages. This suggests a negative relation between surplus cash and equity compensation. Core and Guay (1999) find a negative relation between free cash flow and equity compensation. On the other hand, Ittner et al. (2003) find a positive relation between cash flow and CEO equity grants in new economy firms, as new economy firms with large cash tend to make greater use of equity grants.5 (4) Firm risk. Traditional agency model predicts that the relative weight on a given performance measure is a decreasing function of the noise in the performance measure (Core et al. (2003b, 2003). Thus, managers for risky firms will be given a lower equity-based compensation because it is costly to impose compensation risk on a risk-averse manager. On the other hand, several studies argue that options use may be greater in riskier firms because (a) the convexity of options creates incentive for managers to take higher risk, which may be more significant in riskier firms; (b) to compensate for the higher monitoring cost in noise environment; and (c) to compensate for the reduction of managerial career concern incentives in high risky firms (Prendergast (2000)). Previous empirical studies have found conflicting results on the relation between firm risk and Vega or Delta. Demsetz and Lehn (1985) predict and find a strong positive association between firm risk and Delta. However, Aggarwal and Samwick (1999) argue that greater firm risk reduces Delta, and they find a significant negative relation between firm risk and CEO Delta. Core and Guay (2002b) argue that Aggarwal and Samwick re-document a size effect, and they find a positive effect after choosing an appropriate proxy for firm's risk. Therefore, it is difficult to make a clear priori prediction. (5) Bankruptcy risk. Prior compensation research shows that leverage and bankruptcy risk affect the design of the compensation contract. For example, John and John (1993) show that shareholders optimally lower manger's Delta as leverage increases in order to reduce the expected agency costs of debt. On the other hand, Leland and Pyle (1977) and Choe (2003) find theoretically positive relation between leverage and equity compensation. Empirically, Ortiz-Molina (2007) finds that equity compensation to price sensitivity decreases in straight-debt leverage, but is higher in firms with convertible debt. For financially distressed firms, Gilson and Vetsuypens (1993) find that bankrupt firms increasingly switch to stock options as a compensation method in the years surrounding the bankruptcy or restructuring event. On the other hand, Hayes and Hillegeist (2006) find that the equity compensation to risk sensitivity for newly hired external CEOs is lower for firms with high financial distress risk than for firms with low financial distress risk for the period between 1992-2002. The prediction of bankruptcy risk on managerial compensation is ambiguous.

We identify the SEM by choosing certain instrumental variables for each equation (1) – (3). Based on prior literature, the variables used to identify risky investment equation are: (1) industry investment intensity, (2) market competition, and (3) firm age.

(1) Industry Investment Intensity. Bushee (1998) argues that industry R&D investment intensity captures the investment opportunity set within the firm's industry and the firm's investment spending needed to stay competitive within the industry. He finds that industry investment has a positive effect on firm's R&D investment. In addition, Scharfstein and Stein (1990) examine herd behavior and argue that managerial behavior may be distorted in the direction of herding. Both arguments imply that firm risky investment and industry risky investment are positively related.

(2) Market Competition. On the one hand, in highly concentrated industries, imitation problems are small and R&D is valuable. This implies a positive coefficient should be expected. On the other hand, a dominant firm, when protected by barriers to entry, may have less incentive to innovate to remain competitive. In this case a negative coefficient should be expected. Ryan and Wiggins (2002) find a significant negative relation between a firm's market share and R&D investment. Because there are predictions on both sides, the expected sign is ambiguous. The market competition is proxied by industry Herfindahl index, which is defined as:

$$\text{Herfindahl}_{\text{j}} = \sum_{i=1}^{n} [\frac{s_i}{S_j}]^2$$

, where si is firm i's sales, S is the sum of the sales, si, for all firms in the

5 Another measure of cash constraints is used to check the sensitivity of the results. Following Rajgopal and Shevlin (2002) and Ittner *et al.* (2003), we use the cash balance variable, measured as (cash + marketable securities)/total assets. The results are similar to the main tests.

industry j using both active and inactive firms in Compustat.

(3) Firm age. PÁstor and Pietro (2003) argue that younger firms are usually riskier. Hanlon et al. (2004) find that firm age is significantly negatively related to firm stock return volatility. In addition, CEOs of young firms may have different attitudes as compared to mature firms towards risk taking as they may self-select to invest in new business. We expect the firm age variable to be negatively related to risky investment.

CEO age and tenure are used to identify the Vega and Delta equations. First, Ryan and Wiggins (2002) argue that CEO age proxies inversely for the CEO's time until retirement, and is likely to influence CEO Vega. They argue that compensating CEOs close to retirement with stock options will be ineffective because options have a long incentive horizon and are unlikely to mature during the CEO's employment. Ryan and Wiggins (2002) find that CEO age is significantly negatively related to stock options. Cheng (2004) predicts and finds that compensation committees establish a greater positive association between changes in R&D and changes in CEO option compensation for CEOs with greater than 63 ages (an interaction effect) to prevent opportunistic reductions in R&D expenditure. We focus on the CEO age indicator impact on stock options, and predict a negative relation between them.6 Second, CEO tenure. Ryan and Wiggins (2002) argue that CEO tenure proxies for CEO experience, and is more likely to influence Delta than Vega. CEOs that have held their positions longer are likely to own more shares of stock. We expect the variable to have a positive sign to Delta.

3.5 Descriptive data

Table 1 presents the descriptive data about the investments, CEO compensation, firm's ex ante bankruptcy risk measures, and other firm characteristics for the full sample (Panel A) and for the low and medium bankruptcy risk firms versus high bankruptcy risk firms (Panel B). All the variables are winsorized at the 1st and 99th percentiles to reduce the influence of outliers. Panel A shows that mean (median) Vega is \$108,188 (\$42,758), mean (median) Delta is \$ 622,681 (\$202,329), and mean (median) cash compensation is \$1,278,667 (\$966,800). Compared to previous studies such as Coles et al. (2006), cash compensation and Delta are similar, while the Vega is higher than in their samples. This may be due to the fact that we dropped the zero R&D firms that may have lower Vega incentives. An further examination of samples with the zero R&D firms confirms zero R&D firms have lower Vega incentives. Panel B reports the descriptive statistics for the low and medium bankruptcy risk firms versus high bankruptcy risk firms as well as the results for sample mean difference t-tests and Wilcoxon median difference tests. The mean but not the median of Vega is statistically higher for low and medium bankruptcy risk versus high bankruptcy risk firms. Both mean and median of Delta are significantly higher for low to medium bankruptcy risk firms versus high bankruptcy risk firms. CEO cash compensation is not statistically different for low and medium bankruptcy risk firms relative to high bankruptcy risk firms. For high and low bankruptcy risk firms, CEO age is not significantly different, and CEO tenure is longer in low bankruptcy risk firms than high bankruptcy risk firms. In addition, there is a significant difference in R&D spending across groups. Low and medium bankruptcy risk firms have lower mean R&D spending than high bankruptcy risk firms (not significantly different for median). It seems surprising that high bankruptcy firms on average invest in more risky investment than low bankruptcy firms. However, it is consistent with Joos and Plesko (2005)'s finding that investors price R&D component for persistent loss firms differently. If CEOs make investments knowing this information, then high bankruptcy risk firm CEOs may invest more in R&D than CEOs of low bankruptcy risk firms.

The financial data are also different for the different groups. Comparing high bankruptcy risk firms with low and medium bankruptcy risk firms, sales growth, surplus cash, and stock returns are significantly lower, while debt ratio and firm risk are significantly higher. However, the firm size measured as sales and total assets are not significantly different from those of low bankruptcy risk firms.

4. Empirical Results

4.1 Portfolio test results

Table 2 presents portfolio results for the association between bankruptcy risk and CEO compensation, investments, and other firm characteristics (Table 2 Panel A), as well as the association between investments and decile portfolio of bankruptcy risk for above and below median Vega (Table 2 Panel B). An examination of the portfolio results presents evidence of the risk shifting problem. Panel A of Table 2 presents portfolio results on the association of bankruptcy risk and R&D investments, using Zmijewski (1984)'s financial condition (ZFC) score as a measure for bankruptcy risk. The data reveal that firms' R&D investments and industry-adjusted R&D decrease as the probability of bankruptcy increases from deciles 1 to 7, and increase for deciles 8 to 10. Indeed, mean (median) R&D and industry-adjusted R&D of decile 10 are 16.5% (17.8%) and 12% (13.1) of total asset, which are the highest for the ZFC

6 Since *Delta* consists incentives from restricted stock, stock ownership, and incentive from options, and a major part is stock ownership, they are more likely to be related to CEO tenure rather than CEO age.

portfolios. Results on return volatility for Panel A and B reveal the same pattern as R&D investment intensity.

Results on other firm characteristics also reveal differences for the ten portfolios based on ZFC score. CEO Delta decreases with bankruptcy risk, suggesting that compensation committee adjusts the executive compensation as a firm's other characteristics change (e.g. Ortiz-Molina (2005) and Hayes and Hillegeist (2006)). However, the high bankruptcy risk portfolio 10 is provided with high delta (mean), which is higher than the average of for the total sample. On the other hand, CEO Vega and cash compensation of high bankruptcy risk firms are lower than the average for the respective total samples.

Table 2 Panel B examines the R&D investment for subgroups of bankruptcy risk portfolios based on above or below median Vega and Delta. A firm is defined as high or low Vega (Delta) if the CEO Vega (Delta) is greater or lower than the median Vega (Delta) for all samples available. The data shows that for low and medium bankruptcy risk firms (portfolios 1-7), CEO Vega has a positive impact on R&D and industry-adjusted R&D investments. However, for high bankruptcy risk firms, the pattern reverses. For example, for low bankruptcy risk ZFC portfolio 1, the mean (median) of industry-adjusted R&D for lower Vega firms are 0.030 (0.017), which are significantly lower than 0.043 (0.032) for those of higher Vega firms. On the other hand, for high bankruptcy risk ZFC portfolio 10, the mean (median) of industry-adjusted R&D for lower Vega firms are 0.141 (0.180), which are significantly higher than 0.080 (0.050) for those of higher Vega firms. This suggests that managerial risk incentives have different impact on risk taking for different levels of estimated bankruptcy risk.

Table 1. Descriptive Statistics.
Panel A. Sample Statistics for Full sample

Endogenous Variables					
Variables	Mean	Median	StdD	25th pct	75th pct
Vegat-1(in thousands)	108.188	42.758	178.032	16.099	116.286
Deltat-1(in thousands)	622.681	202.329	1,522.506	85.604	491.784
RD	0.064	0.037	0.069	0.016	0.092
Industry adjusted RD	0.018	0.004	0.065	-0.021	0.037
Financial Data					
Debt ratio	0.188	0.173	0.142	0.074	0.276
Zmijewski (1984)'s ZFC score	-1.414	-1.492	1.613	-2.297	-0.730
CAPX	0.093	0.068	0.086	0.038	0.114
Sales	3,944	1,146	7,493	408	3,854
Sales growth	0.097	0.082	0.243	0.001	0.184
Surplus cash	0.119	0.102	0.111	0.051	0.171
Stock return	19.850	12.880	57.462	(14.147)	39.710
Firm risk (stock return volatility)	0.448	0.386	0.217	0.281	0.568
Market to book	2.295	1.778	1.561	1.356	2.592
Total assets	4,268	1,204	8,180	447	3,861
Tax loss carry forward	0.338	0.000	0.473	0.000	1.000
Firm age	26	19	22	9	36
Herfindahl Index	0.088	0.124	0.023	0.045	0.102
CEO and Governance Data					
Cash compensation	1,279	967	996	583	1,649
CEO Tenure (years)	7.429	5.000	7.085	3.000	10.000
CEO age	55	56	7	51	60
CEO age >=64	0.127	0	0.332	0	0
CEO/Chair	0.700	1	0.458	0	1
Interlock Relation	0.068	0	0.252	0	0
G index	9.583	10	2.658	8	12
G dummy * G index	6.952	8	4.839	0	11

Table 1. Panel B. Sample Statistics for Low to Medium and High Bankruptcy Risk Firms

Endogenous Variables										
	Low to Medium Bankruptcy Risk Firms				High Bankruptcy Risk Firms				t-stat p-value for mean Difference	Wilcoxon p-value for median Difference
	Mean	Median	25th pct	75th pct	Mean	Median	25th pct	75th pct		
Vegat-1(in thousands)	110	43	16	118	88	41	17	101	0.019	0.479
Deltat-1(in thousands)	651	213	90	527	367	132	54	295	0.000	0.000
RD	0.061	0.037	0.016	0.090	0.082	0.034	0.014	0.123	0.000	0.871
Industry adjusted RD	0.015	0.003	-0.021	0.036	0.042	0.004	-0.020	0.066	0.000	0.006
Financial Data										
Zmijewski (1984)'s ZFC score	-1.733	-1.640	-2.408	-0.959	1.500	0.723	0.233	1.633	0.000	0.000
Debt ratio	0.171	0.162	0.066	0.259	0.342	0.323	0.204	0.474	0.000	0.000
CAPX	0.094	0.071	0.040	0.117	0.078	0.044	0.023	0.076	0.000	0.000
Sales (in millions)	3,964	1,125	414	3,623	3,757	1,568	337	5,101	0.599	0.359
Sales growth	0.105	0.087	0.009	0.189	0.029	0.035	-0.118	0.134	0.000	0.000
Surplus cash	0.126	0.107	0.058	0.177	0.049	0.046	-0.022	0.110	0.000	0.000
Stock return	21.491	13.912	-11.763	40.636	4.880	0.512	-37.037	30.815	0.000	0.000
Firm risk (stock return volatility)	0.436	0.380	0.279	0.555	0.555	0.483	0.309	0.784	0.000	0.000
Market to book	2.309	1.799	1.372	2.616	2.167	1.584	1.216	2.280	0.083	0.000
Total assets (in millions)	4,275	1,184	451	3,627	4,201	1,478	421	5,311	0.863	0.275
Firm age	25.756	19	9	35	27.581	16	8	43	0.107	0.802
Herfindahl index	0.088	0.045	0.023	0.102	0.089	0.048	0.027	0.105	0.929	0.146
CEO and Governance Data										
Cash compensation (in thousands)	1,286	975	594	1,650	1,208	900	525	1,591	0.135	0.072
CEO Tenure (years)	7.547	5	3	10	6.350	4	2	9	0.001	0.001
CEO age	55.150	56	51	60	54.953	55	51	59	0.601	0.549
CEO/Chair	0.694	1	0	1	0.749	1	0	1	0.449	0.449
Interlock Relation	0.067	0	0	0	0.077	0	0	0	0.746	0.869
G index	9.588	10	7.917	12	9.535	10	8	11	0.771	0.821
G dummy * G index	6.959	8	0	11	6.885	8	0	10.5	0.001	0.001

Note: This table presents descriptive statistics on the sample firms. All the variables are winsorized at the 1st and 99th percentiles to reduce the influence of outliers. Panel A presents sample statistics for all firms, and panel B presents sample statistics separately for low to median and high bankruptcy risk firms. Bankruptcy risks are calculated as Zmijewski (1984)'s ZFC score.

High bankruptcy risk firms are defined as firms with Zmijewski (1984)'s ZFC score in top 3 deciles for all Compustat firms; otherwise defined as low & medium bankruptcy risk. CEO Vega is measured as the sensitivity of the CEO's option portfolio value to a 1% change in the underlying stock return volatility, where the option value is the Black-Scholes value of a European call option as adjusted for dividends by Merton (1973). CEO Delta is the change in total CEO wealth from a 1% change in stock price, where total CEO wealth is the sum of change in the value of ESO slope incentives, the restricted stock holding incentives, and the normal stock holdings incentives. Both Vega and Delta are measured in logarithms in regressions. RD is R&D expenditures scaled by the firm's average total assets. Industry-adjusted RD is R&D adjusted relative to the median for all sample firms in the same two-digit SIC code for the same sample year. Debt ratio is long-term debt divided by total assets. CAPX is capital expenditure plus acquisitions less sale of PPE scaled by the firm's average total assets. Sales growth is the log of sales to prior-year sales ratio. Firm Size is defined as logarithm of sales. Surplus cash is net cash flow from operating activities less maintenance investment expenditure plus research and development expenditure plus advertising expense, divided by beginning of year book value of total assets. Stock return is one year total return to shareholders, including the monthly reinvestment of dividends. For firms available on ExecuComp, firm risk is measured as bs_volat. When firm's bs_volat is not available on ExecuComp, it is calculated as annualized standard deviation of daily stock returns using the CRSP database. Firm's investment opportunity set is proxied as market to book ratio, which is the market value of equity plus the book value of total asset less book value of common equity, divided by book value of total asset. Firm age is the length of time in years the firm has been publically traded. The firms' start years are obtained from CRSP, while considering the fiscal year effect. Herfindahl index for industry j is defined as: $\text{Herfindahl}_j = \sum_{i=1}^{n} [\frac{s_i}{S_j}]^2$ *, where si is firm i's sales, S is the sum of the sales, si, for all firms in the industry j using both active and inactive firms in Compustat. CEO tenure is the number of years the CEO has become CEO. CEO age is obtained from Execucomp, and supplemented with firm's DEF 14A, obtained from the web version of EDGAR company search. CEO cash compensation is the logarithm of salary plus bonus from ExecuComp. CEO/Chairperson dual leadership is indicator variable that equals to one if CEO is also chair of the board, 0 otherwise. Interlock relation is when executive is listed in the Compensation Committee Interlocks section of the proxy, obtained from Execucomp. G-index is corporate governance index compiled by Gompers et al. (2003) based on 24 corporate governance provisions collected by IRRC. G-INDEX is available for 1990, 1993, 1995, 1998, 2000, 2002 and 2004. Linear extrapolation is used to fill in the missing years for firms with available G-INDEX. G-dummy Equals to 1 if a G-INDEX is present for the firm-year, and 0 otherwise.*

Table 2. Panel A. Zmijewski (1984)'s ZFC index Portfolio Results (Mean)

Zmijewski (1984)'s ZFC score Port	Zmijewski (1984)'s ZFC score	CEO Vegat-1	CEO Delta t-1	RD	Industry-adjusted RD	Capx	Sales	Sales growth	Surplus Cash	Stock Return	Return Volatility	Market to book
1	-3.469	96	1,012	0.095	0.036	0.094	1,566	0.197	0.193	35.496	0.565	3.564
2	-2.547	93	764	0.080	0.026	0.098	1,918	0.130	0.154	26.164	0.470	2.546
3	-1.991	112	680	0.068	0.021	0.093	3,606	0.110	0.145	21.916	0.429	2.458
4	-1.517	104	461	0.051	0.009	0.093	4,968	0.079	0.111	17.374	0.399	2.002
5	-1.097	107	578	0.047	0.004	0.095	4,511	0.079	0.098	21.068	0.402	1.865
6	-0.692	127	490	0.040	0.001	0.095	5,140	0.068	0.081	12.570	0.388	1.703
7	-0.241	146	536	0.042	0.005	0.090	7,015	0.055	0.087	12.349	0.387	1.831
8	0.342	106	335	0.060	0.021	0.091	5,097	0.077	0.078	5.106	0.452	1.932
9	1.695	56	232	0.093	0.051	0.068	2,474	-0.044	0.031	6.552	0.654	2.045
10	6.972	95	956	0.165	0.120	0.045	715	0.002	-0.046	-1.522	0.788	3.782
Total	-1.414	108	623	0.064	0.018	0.093	3,944	0.097	0.119	19.850	0.448	2.295
Observations	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079
Zmijewski (1984)'s ZFC score Port	Total assets	Firm age	Herfindahl index	Cash compensation	CEO tenure	CEO age	CEO /Chair	Interlock relation	G index	G dummy * G index	Convertible debt	obs
1	2,194	14.431	0.045	953	9.124	53.011	0.552	0.105	8.981	4.922	0.008	531
2	2,069	17.724	0.077	1,105	7.687	54.616	0.618	0.086	8.951	6.279	0.028	536
3	3,803	23.948	0.081	1,285	8.098	54.832	0.648	0.061	9.143	6.695	0.046	620
4	5,098	27.542	0.102	1,318	7.157	55.159	0.724	0.058	9.633	7.308	0.039	605
5	4,695	30.013	0.103	1,348	7.054	55.888	0.760	0.067	10.232	7.872	0.042	555
6	5,545	34.246	0.102	1,457	7.095	56.646	0.785	0.044	10.161	7.958	0.036	452
7	7,657	36.785	0.117	1,671	6.117	56.549	0.825	0.037	9.981	8.128	0.023	377
8	5,805	32.482	0.088	1,455	6.115	55.668	0.765	0.080	9.802	7.547	0.037	226
9	2,536	23.478	0.096	984	6.701	54.052	0.739	0.090	9.255	6.423	0.090	134
10	958	14.605	0.073	613	6.488	54.000	0.698	0.023	8.684	4.847	0.205	43
Total	4,268	25.936	0.088	1,279	7.429	55.130	0.700	0.068	9.583	6.952	0.037	
Observations	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079

Table 2. Panel A (cont.). Zmijewski (1984)'s ZFC index Portfolio Results (Median)

Zmijewski (1984)'s ZFC score Port	Zmijewski (1984)'s ZFC score	CEO Vegat-1	CEO Deltat-1	RD	Industry-adjusted RD	Capx	Sales	Sales growth	Surplus cash	Stock return	Stock return volatility	Market to book	Total assets
1	-3.394	29.285	275	0.086	0.023	0.076	352	0.168	0.179	17.647	0.555	2.907	424
2	-2.544	36.579	226	0.062	0.013	0.075	661	0.113	0.139	15.121	0.442	2.117	783
3	-1.991	39.778	206	0.046	0.007	0.077	953	0.091	0.127	15.161	0.376	1.984	935
4	-1.522	41.928	199	0.029	0.001	0.071	1,222	0.076	0.096	12.558	0.345	1.704	1,210
5	-1.093	48.405	182	0.027	0.000	0.072	1,573	0.067	0.083	14.893	0.351	1.615	1,693
6	-0.715	52.941	195	0.026	-0.002	0.065	1,906	0.061	0.069	10.169	0.330	1.439	1,893
7	-0.279	74.292	227	0.024	0.000	0.057	4,111	0.044	0.072	10.736	0.342	1.503	4,090
8	0.265	50.387	154	0.026	0.000	0.051	3,244	0.049	0.072	5.799	0.364	1.541	2,866
9	1.504	27.831	105	0.049	0.014	0.038	761	-0.015	0.019	-3.150	0.565	1.504	857
10	5.565	26.303	90	0.178	0.131	0.032	214	-0.027	-0.032	-37.037	0.827	2.471	412
Total	-1.492	42.758	202	0.037	0.004	0.068	1,146	0.082	0.102	12.880	0.386	1.778	1,204
Observations	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079	4,079
Zmijewski (1984)'s ZFC score Port	Tax Loss carry forward	Firm age	Herfindahl index	Cash compensation	CEO tenure	CEO age	CEO age >=64	CEO /Chair	Interlock relation	G index	G dummy * G index	Convertible debt	obs
1	0	12	0.037	699	7	53	0	1	0	9	6	0.000	531
2	0	14	0.042	792	5	55	0	1	0	9	8	0.000	536
3	0	18	0.041	931	5	55	0	1	0	9	8	0.000	620
4	0	25	0.048	1,013	5	55	0	1	0	10	8	0.000	605
5	0	27	0.052	1,135	5	56	0	1	0	10	9	0.000	555
6	0	28	0.055	1,109	5	57	0	1	0	10	9	0.000	452
7	0	33	0.059	1,402	4	57	0	1	0	10	9	0.000	377
8	0	30	0.050	1,175	4	56	0	1	0	10	9	0.000	226
9	0	14	0.047	730	4	54	0	1	0	10	8	0.000	134
10	1	11	0.047	530	4	55	0	1	0	9	6	0.576	43
Total	0	19	0.045	967	5	56	0	1	0	10	8	0.000	
Observations	0	12	0.037	699	7	53	0	1	0	9	6	0.000	4,079

Note: Data definitions please refer to Table 1. Portfolio is based on Zmijewski (1984)'s ZFC score from all Compustat data. The portfolio 1 is low bankruptcy risk, and portfolio 10 is the highest bankruptcy risk. The table shows that RD, industry adjusted RD, and stock return volatility are highest for portfolio 10.

Table 2. Panel B. Firms' R&D investments for high and low bankruptcy risk and high and low Vega

CEO Vegat-1		Zmijewski (1984)'s ZFC score port 1 (LOW)	2	3	4	5	6	7	8	9	Zmijewski (1984)'s ZFC score port 10 (HIGH)
LOW	Mean RD	0.091	0.077	0.066	0.055	0.047	0.041	0.049	0.083	0.109	0.185
	Median RD	0.077	0.047	0.044	0.030	0.027	0.024	0.020	0.029	0.053	0.227
	SD	0.071	0.074	0.070	0.068	0.062	0.055	0.077	0.107	0.114	0.135
	N	320	292	317	306	261	198	138	102	77	28
HIGH	Mean RD	0.101	0.084	0.069	0.047	0.046	0.039	0.037	0.042	0.072	0.127
	Median RD	0.091	0.076	0.050	0.028	0.027	0.027	0.025	0.024	0.035	0.111
	SD	0.063	0.059	0.060	0.049	0.052	0.039	0.046	0.054	0.067	0.106
	N	211	244	303	299	294	254	239	124	57	15
Total	Mean RD	0.095	0.08	0.068	0.051	0.047	0.04	0.042	0.06	0.093	0.165
	Median RD	0.086	0.062	0.046	0.029	0.027	0.026	0.024	0.026	0.049	0.178
	SD	0.068	0.068	0.065	0.059	0.057	0.047	0.06	0.084	0.098	0.128
	N	531	536	620	605	555	452	377	226	134	43
P-value for Test of Mean Difference (two-tailed)		0.099	0.204	0.580	0.085	0.802	0.690	0.061	0.000	0.033	0.157
P-value for Wilcoxon Test for Median Difference		0.022	0.004	0.112	0.689	0.247	0.170	0.485	0.123	0.518	0.123

Table 2. Panel B (cont.). Industry-adjusted R&D investments for high and low bankruptcy risk and high and low Vega

CEO Vegat-1		Zmijewski (1984)'s ZFC score port 1 (LOW)	2	3	4	5	6	7	8	9	Zmijewski (1984)'s ZFC score port 10 (HIGH)
LOW	Mean	0.030	0.024	0.018	0.011	0.004	-0.001	0.010	0.039	0.069	0.141
	Median	0.017	0.006	0.005	0.001	0.000	-0.008	0.000	0.001	0.013	0.180
	SD	0.071	0.070	0.067	0.064	0.059	0.053	0.077	0.101	0.104	0.130
	N	320	292	317	306	261	198	138	102	77	28
HIGH	Mean	0.043	0.028	0.024	0.005	0.004	0.002	0.002	0.006	0.027	0.080
	Median	0.032	0.018	0.012	0.002	0.001	0.000	0.000	0.000	0.015	0.050
	SD	0.064	0.059	0.057	0.045	0.049	0.036	0.043	0.054	0.065	0.111
	N	211	244	303	299	294	254	239	124	57	15
Total	Mean	0.036	0.026	0.021	0.009	0.004	0.001	0.005	0.021	0.051	0.120
	Median	0.023	0.013	0.007	0.001	0.000	-0.002	0.000	0.000	0.014	0.131
	SD	0.068	0.065	0.062	0.055	0.054	0.044	0.058	0.080	0.091	0.126
	N	0.036	0.026	0.021	0.009	0.004	0.001	0.005	0.021	0.051	0.120
P-value for Test of Mean Difference (two-tailed)		0.032	0.494	0.223	0.184	0.952	0.492	0.219	0.002	0.008	0.130
P-value for Wilcoxon Test for Median Difference		0.005	0.052	0.007	0.881	0.298	0.023	0.727	0.336	0.071	0.068

Note: This table presents the portfolio tests of R&D (panel A) and industry-adjusted R&D (panel B) for different bankruptcy risk portfolios based on above or below median Vega. A firm is defined as high (low) Vega if the CEO Vega is greater (lower) than the median Vega for all data available.

4.2 Regressions of equity-based compensation on risk taking for High vs. low and median bankruptcy risk firms

Based on the conceptual model in the system of equations (1) – (3), the following SEMs are estimated using three-stage-least-squares and controlled for industry and year dummies to test the hypothesis:

Risky Investmentt = a0 + α1 LoDR X Vegat-1 + α2 LoDR X Deltat-1 + α3 HiDR + α4 HiDR X Vegat-1 + α5 HiDR X Deltat-1 + α6 Firm sizet + α7 Market to Book t + α8 Surplus Casht + α9 Firm risk + α10 Industry median RD + α11 Herfindahl Index + α12 Firm aget +Industry + Year + error t (5)

Vegat-1 = β0 +β1 Risky Investmentt + β2 Deltat-1 + β3 HiDR + β4 Firm sizet + β5 Market to Book t + β6 Surplus Casht + β7 Firm risk + β8CEO Age + β9 CEO Cash compensation + β10 CEO/Chair + β11 G dummy + β12 G dummy X G index +Industry + Year + error t (6)

Deltat-1 = γ0 + γ1 Risky Investmentt + γ2 Vegat-1 + γ3 HiDR + γ4 Firm sizet + γ5 Market to Book t + γ6 Surplus Casht + γ7 Firm risk + γ8 CEO Tenure + γ9 CEO Cash compensation + γ10 CEO/Chair + γ11 G dummy + γ12 G dummy X G index +Industry + Year + error t (7)

Referring to equation (4), if the null hypothesis H1 is valid, we expect α1 > or < α4 and α2 < α5. If α1 < α4, options aggravate or do not solve the risk shifting problem; or, if α1 > α4 options solves the risk shifting problem. In addition, we expect β1 >0: other factors being equal, firms with higher incentives for risk taking will provide higher Vega to CEOs.

As a first step, Table 3 reports the results of the estimation of the ordinal least square (OLS) regressions of R&D and industry-adjusted R&D on lag Vega and Delta for high bankruptcy risk and low and median bankruptcy risk firms, respectively. The results show that Vega (Delta) is significantly positively (negatively) associated with R&D and industry-adjusted R&D for low-median bankruptcy risk firms. However, Vega (Delta) is negatively (positively) associated with R&D and industry-adjusted R&D for high bankruptcy risk firms, although statistically insignificant at conventional levels.

Table 3. Ordinary least squares (OLS) regressions of risky investment intensity on lag CEO risk incentive for high bankruptcy risk relative to low and medium bankruptcy risk firms

Dependent variable	Panel A: RD		Panel B: Industry-Adjusted RD	
	low to median bankruptcy risk firm	high bankruptcy risk firm	low to median bankruptcy risk firm	high bankruptcy risk firm
Intercept	0.056*** (5.56)	0.221*** (6.29)	0.045*** (5.12)	0.167*** (5.49)
CEO Vegat-1	0.062*** (7.76)	-0.015 (-0.38)	0.073*** (8.61)	-0.017 (-0.44)
CEO Delta t-1	-0.013*** (-5.57)	0.020 (1.47)	-0.017*** (-7.22)	0.014 (0.95)
Firm size	-0.010*** (-11.99)	-0.030*** (-9.97)	-0.009*** (-10.13)	-0.027*** (-9.10)
Market to book	0.006*** (5.43)	0.015*** (5.55)	0.006*** (5.61)	0.016*** (6.80)
Surplus cash	0.217*** (15.02)	0.164*** (4.02)	0.199*** (13.00)	0.151*** (4.16)
Firm risk	0.031*** (18.04)	0.029*** (3.58)	0.020*** (11.69)	0.025*** (3.32)
Industry/Year fixed effects	Both Included	Both Included	Year Included	Year Included
Adjusted R2	0.475	0.618	0.312	0.578
Number of observations	3676	403	3676	403

Note: The following regressions are estimated:

INVESTMENTt = a0 + α1 Vegat-1 + α2 Deltat-1 + α3 Firm sizet + α4 Market to Book t + α5 Surplus Casht + α6 Firm risk +Industry + Year + error t *(4')*

*The dependent variables are R&D expenditure (panel A) and industry-adjusted R&D expenditure (panel B), both normalized by total assets. Data definitions please refer to Table 1. The t statistics are in parenthesis. ***/**/* denote the significance at the 0.01/0.05/0.10 level.*

Table 4 shows different regression specifications on R&D and industry-adjusted R&D on the interactive variable for lag CEO incentives and high bankruptcy risk relative to low and medium bankruptcy risk. Results show that the bankruptcy risk dummy is significantly positive, suggesting that high financial bankruptcy risk firms have higher R&D investment if the explanatory variables are set to zero. In addition, all the specifications show significantly lower impact of Vega for high bankruptcy risk firms relative to low bankruptcy risk firms, and significantly higher impact of Delta for high bankruptcy risk firms relative to low bankruptcy risk firms. The results suggest that Vega mitigates managerial risk taking for high bankruptcy risk firms than low and median bankruptcy risk firms. On the other hand, Delta aggravates managerial risk taking for high bankruptcy risk firms than low and median bankruptcy risk firms, which is consistent with hypothesis 2.

Table 4. Regressions of risky investment intensity on interactive variable for lag CEO risk incentive and high bankruptcy risk relative to low and medium bankruptcy risk

Dependent variable	RD		Industry-Adjusted RD	
	robust test	median test	robust test	median test
Intercept	0.098*** (8.74)	0.017 (1.00)	0.060*** (7.26)	0.007 (1.18)
LoDR (1-7) X CEO Vega t-1	0.078*** (9.66)	0.044*** (6.18)	0.090*** (10.53)	0.056*** (6.70)
LoDR (1-7) X CEO Delta t-1	-0.014*** (-5.58)	-0.010*** (-4.77)	-0.018*** (-7.29)	-0.015*** (-6.34)
HiDR (8-10) dummy	0.038*** (7.65)	0.012*** (4.13)	0.044*** (8.98)	0.020*** (5.75)
HiDR (8-10) X CEO Vegat-1	-0.125*** (-4.31)	-0.088*** (-3.40)	-0.141*** (-4.89)	-0.099*** (-3.09)
HiDR (8-10) X CEO Deltat-1	0.032*** (2.75)	0.039*** (4.71)	0.028** (2.37)	0.023** (2.22)
Firm size	-0.014*** (-16.53)	-0.006*** (-11.35)	-0.013*** (-14.25)	-0.005*** (-8.18)
Market to book	0.008*** (8.36)	0.007*** (13.21)	0.009*** (8.76)	0.005*** (7.61)
Surplus cash	0.190*** (14.18)	0.191*** (26.34)	0.171*** (12.24)	0.170*** (19.60)
Firm risk	0.028*** (16.21)	0.019*** (11.13)	0.018*** (10.21)	0.015*** (7.62)
Industry/Year fixed effects	Both Included	Both Included	Year Included	Year Included
Adjusted R2	0.479	0.274	0.341	0.111
Observations	4079	4079	4079	4079
p-value for test LoDR X CEO Vegat-1 = HiDR (8-10) X CEO Vegat-1	0.000	0.000	0.000	0.000
p-value for test LoDR X CEO Vegat-1 = HiDR (8-10) X CEO Deltat-1	0.000	0.000	0.000	0.000

Note: The following regressions are estimated:

Risky Investmentt = α0 + α1 LoDR X Vegat-1 + α2 LoDR X Deltat-1 + α3 HiDR + α4 HiDR X Vegat-1 + α5 HiDR X Deltat-1 + α6 Firm sizet + α7 Market to Book t + α8 Surplus Casht + α9 Firm risk + Industry + Year + error t (4'')

*where LoDR = 1 if the firms fall in the deciles 1-7 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. HiDR = 1 if the firms fall in the deciles 8-10 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. Data definition please refers to Table 1. The t statistics are in parenthesis. ***/**/* denote the significance at the 0.01/0.05/0.10 level. The p-values for test of the equality of the coefficients are reported in the last two rows.*

Table 5 provides the estimation result using simultaneous equations model and control for industry and year effect. The result shows that Vega on average increases risk taking (α1 = 0.287, t=47.44 and α4 = 0.211, t=9.08), and Delta on average reduces risk taking (α2 = -0.074, t=-33.69 and α5 = -0.057, t=-7.33). The coefficient on the LoDR dummy * Vegat-1 interaction term (α1 = 0.287, t=47.44) is significantly higher than the HiDR dummy * Vegat-1 interaction term (α4=0.211, t=9.08) at 1% significant level. It suggests that even after controlling for the other factors that are considered to affect the R&D expenditures, options may be used to reduce the leverage-induced risk shifting problem – the agency problem between bondholders and managers. The coefficient on the LoDR dummy * Deltat-1 interaction term (α2 = -0.074, t=-33.69) is significantly less than HiDR dummy * Deltat-1 interaction term (α5 = -0.057, t=-7.33) the which suggests that Delta fully aligns shareholder and managers interests and aggravate the leverage induced risk shifting problem.

For the determinants of CEO Vega and Delta, the results show that for firms with high R&D, CEOs are given higher Vega (β1 = 2.399, t=23.92) and lower Delta (γ1 =-4.977, t=-16.88). The results suggest that managers in risky firms are given high risk-based compensation and low price-based compensation. In addition, high bankruptcy risk firms are given less Vega (β3 = -0.062, t=-8.51) and higher Delta (γ3 =0.092, t=4.55).

Table 5. Simultaneous equation regressions of risky investment intensity on interactive variables between lag CEO risk incentive and high vs. low and medium bankruptcy risk firms

	R&D	CEO Vegat-1	CEO Deltat-1
Intercept	0.116*** (22.26)	-0.255*** (-11.99)	0.212*** (4.48)
R&D		2.399*** (23.92)	-4.977*** (-16.88)
CEO Vega t-1			2.293*** (52.85)
CEO Deltat-1		0.257*** (53.33)	
LoDR X CEO Vegat-1	0.287*** (47.44)		
LoDR X CEO Deltat-1	-0.074*** (-33.69)		
HiDR (8-10) dummy	0.031*** (9.93)	-0.062*** (-8.15)	0.092*** (4.55)
HiDR (8-10) X CEO Vegat-1	0.211*** (9.08)		
HiDR (8-10) X CEO Deltat-1	-0.057*** (-7.33)		
Firm size	-0.018*** (-27.16)	0.042*** (18.43)	-0.041*** (-5.90)
Market to book	0.012*** (19.09)	-0.034*** (-18.59)	0.109*** (23.35)
Surplus cash	0.203*** (23.95)	-0.503*** (-17.13)	1.094*** (13.43)
Firm risk	0.029*** (15.55)	-0.072*** (-13.39)	0.190*** (13.11)
Industry Median R&D	0.143*** (5.63)		
HERF	-0.010** (-2.10)		
Firm Age	0.000 (1.13)		
CEO age		-0.001*** (-3.58)	
CEO tenure			0.011*** (15.61)
Cash compensation		0.052*** (8.77)	-0.123*** (-6.21)
CEO/Chair duality		-0.006* (-1.71)	0.034*** (3.07)
G dummy		-0.044*** (-5.91)	0.231*** (9.41)
G dummy X G index		0.004*** (5.78)	-0.021*** (-9.50)
2-digit SIC and year dummies	Both Included	Both Included	Both Included
Observations	4,079	4,079	4,079
p-value for test LoDR X CEO Vegat-1 = HiDR (8-10) X CEO Vegat-1	0.002		
p-value for test LoDR X CEO Deltat-1 = HiDR (8-10) X CEO Deltat-1	0.028		

Note: The following simultaneous regressions are estimated using 3SLS. and controlling for industry and year dummies.

Risky Investmentt = α0 + α1 LoDR X Vegat-1 + α2 LoDR X Deltat-1 + α3 HiDR + α4 HiDR X Vegat-1 + α5 HiDR X Deltat-1 + α6 Firm sizet + α7 Market to Book t + α8 Surplus Casht + α9 Firm risk + α10 Industry median RD + α11 Herfindahl Index + α12 Firm aget +Industry + Year + error t

Vegat-1 = β0 +β1 Risky Investmentt + β2 Deltat-1 + β3 HiDR + β4 Firm sizet + β5 Market to Book t + β6 Surplus Casht + β7 Firm risk + β8CEO Age + β9 CEO Cash compensation + β10 CEO/Chair + β11 G dummy + β12 G dummy X G index +Industry + Year + error t

Deltat-1 = γ0 + γ1 Risky Investmentt + γ2 Vegat-1 + γ3 HiDR + γ4 Firm sizet + γ5 Market to Book t + γ6 Surplus Casht + γ7 Firm risk + γ8 CEO Tenure + γ9 CEO Cash compensation + γ10 CEO/Chair + γ11 G dummy + γ12 G dummy X G index +Industry + Year + error t

*where LoDR = 1 if the firms fall in the deciles 1-7 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. HiDR = 1 if the firms fall in the deciles 8-10 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. Data definition please refers to Table 1. The z statistics are in parenthesis. ***/**/* denote the significance at the 0.01/0.05/0.10 level. The p-values for test of the equality of the coefficients are reported in the last two rows.*

Robustness tests show that alternative partitions of high bankruptcy risk relative to low or medium bankruptcy risk such as low ZFC deciles (1-3), medium ZFC deciles (4-7), and high ZFC deciles (8-10) and low ZFC deciles (1-6) and high ZFC deciles (7-10) provide similar results. In general, Vega has a positive impact on managerial risk taking. However, the impact is lower for high bankruptcy risk firms relative to low or medium bankruptcy risk firms.

5. Sensitivity Tests

5.1 Alternative measures of variables

First, we conduct analysis using alternative measures of firm's ex ante bankruptcy risk, including Ohlson (1980)'s O-score, Altman's (1968) Z-score, Begley et al. (1996) updated Z score, and S&P credit ratings. The unreported results show that the main results using alternative measures are not changed. Second, we measure firm's risk using stock return volatility and the main results are not changed.

5.2 The usage of convertible debt

Haugen and Senbet (1981), Green (1984) and John and John (1993) argue that convertible debt mitigates risk shifting incentive because the benefits of increasing volatility accrue to the convertible debtholders who are not managers. If a firm uses convertible debt to reduce the risk shifting problem when face high bankruptcy risk, stock and stock option compensation should have the same impact on firms with and without risk shifting problem.

In order to investigate whether managers in firms with convertible debt act differently when they face high bankruptcy risk, we conduct the following two test. First, we separate the sample firms into straight debt and convertible debt firms, and perform the main tests for each subsample with consecutively reducing the lower 25th and 50th percentiles debt ratio (or convertible debt ratio), respectively. Convertible debt is defined as 1 if the convertible debt/total assets is greater than zero, and 0 otherwise. For firms with convertible debt, since the risk shifting problem has been mitigated, Vega and Delta are expected to have same impacts on managerial risk taking choices for high bankruptcy risk firms relative to low bankruptcy risk firms. On the other hand, for firms without convertible debt, Vega and Delta are expected to induce differential managerial risk taking. Second, we include an additional control variable, the proportion of convertible debt as a percentage of total long-term debt,7 in the simultaneous estimation equations to control for the nature of the debt.

Table 6 provides the descriptive statistics for firms with and without convertible debt. As shown in the table, about 21% (827/4,019) of the sample issued convertible debt. Consistent with Ortiz-Molina (2007), convertible firms have higher Vega and Delta. Firms with convertible debt have significant higher R&D, debt ratio, bankruptcy risk, firm risk, sales growth, and market to book ratio than firms without convertible debt. The Delta and total assets are not significantly different for firms with and without convertible debt.

Table 7 presents estimation results on straight debt only firms and firms with convertible debts for whole group, excluding firms below the 25th percentile, and excluding firms below the 50th percentile. The results show that for straight debt firms, there exists a significant difference between the interactions of Vega with low bankruptcy risk (LoDR) and high bankruptcy risk (HiDR). However, for convertible debt financed firms, the differences are insignificant. This suggests that convertible debt can be used as a mechanism to control for the risk shifting problem. In addition, the interactions of Delta with high and low bankruptcy risk dummy show significant higher impact for high bankruptcy risk relative to low bankruptcy risk firms for straight debt only firms, consistent with the prediction that Delta fully aligns the manager's and shareholders' interests and aggravates the risk shifting problem. However, for convertible debt financed firms, the differences are insignificant. The results are consistent with the prediction that convertible debt can be used as a mechanism to control for the asset substitution problem. In addition, Unreported results show that the main results do not change after including the convertible debt variable in the estimation equation.

5.3 CEOs with at least three-year observations

A concern with using end of year CEO compensation data is that the CEO's cash and equity compensation may only represent part of the compensation. In addition, new CEOs may have different incentives than incumbent CEOs. In order to address this concern, we perform the same main tests using only CEOs with at least three years of observations. The unreported results show that the inferences reported in the text are unchanged.

5.4 Contemporaneous managerial risk taking incentives

Prior studies also examine contemporaneous relation between managerial compensation and risk taking incentives, such as Coles et al. (2006). In the sense that CEOs make decisions on risky investment contemporaneously, we perform the same test using contemporaneous R&D investments and Vega and Delta. Unreported results show that the main results remain unchanged.

[7] Additional tests by including convertible debt to total asset ratio (data79/data6) as control variable in all equations provide similar results.

Table 6. Descriptive statistics for firms with and without convertible debt

	Firms with convertible debt (n=827)		Firms without convertible debt (n=4,019)		t-stat p-value for Difference	Wilcoxon p-value for Difference
Variables	Mean	Median	Mean	Median		
Vegat-1(in thousands)	123	58	104	40	0.006	0.000
Deltat-1(in thousands)	676	264	598	185	0.182	0.000
RD	0.092	0.076	0.056	0.031	0.000	0.000
Industry adjusted RD	0.037	0.021	0.012	0.001	0.000	0.000
Debt ratio	0.261	0.248	0.171	0.152	0.000	0.000
Zmijewski (1984)'s ZFC score	-1.049	-1.406	-1.502	-1.504	0.000	0.000
CAPX	0.087	0.060	0.094	0.070	0.024	0.000
Sales (in millions)	3,377	766	4,105	1,235	0.013	0.000
Sales growth	0.119	0.114	0.093	0.077	0.005	0.000
Surplus cash	0.103	0.098	0.123	0.103	0.000	0.000
Stock return	22.477	10.163	19.186	13.580	0.142	0.195
Firm risk (stock return volatility)	0.591	0.572	0.410	0.355	0.000	0.000
Market to book	2.457	1.847	2.252	1.757	0.001	0.000
Total assets (in millions)	4,035	1,141	4,344	1,220	0.336	0.752
Firm age	20.446	14.000	27.410	23.000	0.000	0.000
Herfindahl index	0.065	0.039	0.095	0.048	0.000	0.000
Cash compensation (in thousands)	1,143	837	1,309	1,011	0.000	0.000
CEO Tenure (years)	7.889	5.000	7.292	5.000	0.031	0.016
CEO age	53.727	54.000	55.585	56.000	0.000	0.000
CEO age >=64	0.112	0	0.132	0	0.130	0.130
CEO/Chair	0.626	1.000	0.716	1.000	0.000	0.000
Interlock relation	0.058	0	0.071	0	0.195	0.194
G index	9.038	9.000	9.707	10.000	0.000	0.000
G dummy * G index	6.262	7.500	7.122	8.000	0.000	0.000
Convertible debt as a percentage of long-term debt (convdebt)	0.754	0.902	0	0	0.000	0.000

Note: Data definitions please refer to Table 1. Firms are defined as without convertible debt if their convertible debts are zero or missing. Otherwise, they are defined as firms with convertible debt.

5.5 Young firms and high growth firms

It is possible that the differential impacts of Vega on managerial risk taking are due to young or high growth firms rather than bankruptcy risk since young or high growth firms are more likely to have high bankruptcy risk, and more likely to provide high equity compensation to CEOs. In addition, firms with high business risk and growth opportunities tend to have lower debt ratio (Smith and Watts (1992)).

In order to investigate these issues, we separate the firms into startup and other firms, and high and low growth firms subsamples, respectively, and conduct the main tests. If the main results are due to firm age or industry, we will not find significant results for each subsample. We define start-up firms as firms with less than 6 years listed in CRSP. Following prior literature, such as Francis and Schipper (1999) and Ryan and Wiggins (2002), the high growth firms are defined as firms in the drugs (SIC 283), computer (SIC 357), and high technology (SIC 360-369), and software (737). The low-technology sample includes construction (SIC 160 and 170), light manufacturing (SIC 200-282, and 284-339), heavy manufacturing (SIC 340-356), motor vehicles (SIC 371), miscellaneous manufacturing industries (399), and grocery stores (SIC 541). Table 8 Panel A and B provide the descriptive statistics on the industry allocation and startup firms for the ten Zmijewski (1984)'s ZFC deciles. The data shows that the high growth firms have a nearly monotonically decreasing trend for bankruptcy risk deciles. On the other hand, low growth firms exhibit inverse U-Shape for bankruptcy risk deciles. Table 8 Panel B presents the data on bankruptcy risk deciles and startup firms. The start-up firms exhibit U-shape, with higher percentages for deciles 1-2 and 9-10. The average firm age is smaller for low and high ZFC deciles.

Unreported simultaneous regression results for the high versus low bankruptcy risk (decile 8-10 versus deciles 1-7) for high- and low- growth firms and above- and below- average age firms show that

CEO Vega has significant different impact on managerial risk taking for high and low bankruptcy risk for both high and low growth firms and non-startup firms, and are insignificant for start-up firms.

Table 7. Simultaneous equation regressions of risky investment intensity on interactive variables for firms with and without convertible debt

	RD Investment for Firms with Straight debt only			RD Investment for Firms with convertible debt		
	Whole group	Exclude lower 25th pct debt ratio	Exclude lower 50th pct debt ratio	Whole group	Excluding low 25th pct of convertible debt ratio	Excluding low 50th pct of convertible debt ratio
Intercept	0.100*** (17.73)	0.063*** (10.60)	0.051*** (7.67)	0.165*** (12.18)	0.160*** (9.94)	0.189*** (9.02)
LoDR (1-7) X CEO Vegat-1	0.261*** (36.56)	0.145*** (18.19)	0.019** (2.09)	0.318*** (21.21)	0.304*** (15.88)	0.320*** (10.97)
LoDR (1-7) X CEO Deltat-1	-0.068*** (-28.68)	-0.042*** (-15.34)	0.012*** (3.84)	-0.079*** (-14.70)	-0.058*** (-10.08)	-0.015** (-2.12)
HiDR (8-10) dummy	0.019*** (5.27)	0.014*** (4.13)	0.018*** (5.49)	0.055*** (7.86)	0.069*** (8.55)	0.089*** (9.11)
HiDR (8-10) X CEO Vegat-1	0.176*** (6.59)	0.027 (0.96)	-0.138*** (-5.27)	0.209*** (2.72)	0.177 (1.62)	0.223 (1.50)
HiDR (8-10) X CEO Deltat-1	-0.046*** (-4.98)	-0.004 (-0.41)	0.067*** (6.33)	-0.058*** (-2.85)	-0.036 (-1.45)	-0.013 (-0.38)
Firm size	-0.017*** (-22.18)	-0.012*** (-14.96)	-0.010*** (-11.41)	-0.023*** (-14.27)	-0.025*** (-12.52)	-0.029*** (-11.18)
Market to book	0.011*** (16.49)	0.013*** (14.26)	0.013*** (12.56)	0.009*** (7.03)	0.006*** (4.52)	0.006*** (3.26)
Surplus cash	0.209*** (22.91)	0.156*** (14.96)	0.053*** (4.38)	0.219*** (10.48)	0.237*** (10.63)	0.235*** (8.19)
Firm risk	0.024*** (12.50)	0.018*** (9.69)	0.006*** (3.37)	0.028*** (4.91)	0.036*** (4.90)	0.020** (2.03)
Industry Median R&D	0.203*** (7.00)	0.321*** (10.75)	0.353*** (11.45)	0.150** (2.16)	0.236*** (2.61)	0.157 (1.41)
HERF	-0.012** (-2.05)	-0.015*** (-2.71)	-0.008 (-1.44)	-0.029* (-1.85)	-0.050** (-2.16)	-0.046 (-1.09)
Firm Age	0.000* (1.71)	0.000*** (3.52)	0.000*** (4.35)	0.000 (0.22)	-0.000 (-0.53)	-0.000 (-0.26)
Observations	3,252	2,439	1,633	827	681	473
p-value for test LoDR X Vegat-1 = HiDR X Vegat-1	0.002	0.000	0.000	0.165	0.248	0.513
p-value for test LoDR X Deltat-1 = HiDR X Deltat-1	0.016	0.001	0.000	0.296	0.395	0.945

Note: The following simultaneous regressions are estimated using 3SLS and controlling for industry and year dummies.
Risky Investmentt = α0 + α1 LoDR X Vegat-1 + α2 LoDR X Deltat-1 + α3 HiDR + α4 HiDR X Vegat-1 + α5 HiDR X Deltat-1 + α6 Firm sizet + α7 Market to Book t + α8 Surplus Casht + α9 Firm risk + α10 Industry median RD + α11 Herfindahl Index + α12 Firm aget +Industry + Year + error t
Vegat-1 = β0 +β1 Risky Investmentt + β2 Deltat-1 + β3 HiDR + β4 Firm sizet + β5 Market to Book t + β6 Surplus Casht + β7 Firm risk + β8CEO Age + β9 CEO Cash compensation + β10 CEO/Chair + β11 G dummy + β12 G dummy X G index +Industry + Year + error t
Deltat-1 = γ0 + γ1 Risky Investmentt + γ2 Vegat-1 + γ3 HiDR + γ4 Firm sizet + γ5 Market to Book t + γ6 Surplus Casht + γ7 Firm risk + γ8 CEO Tenure + γ9 CEO Cash compensation + γ10 CEO/Chair + γ11 G dummy + γ12 G dummy X G index +Industry + Year + error t
*where LoDR = 1 if the firms fall in the deciles 1-7 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. HiDR = 1 if the firms fall in the deciles 8-10 of the calculated Zmijewski (1984)'s ZFC score based on all Compustat firms, and 0 otherwise. The estimation results for Vega and Delta equations are not reported. The t statistics are in parenthesis. ***/**/* denote the significance at the 0.01/0.05/0.10 level. The p-values for test of the equality of the coefficients are reported in the last two rows.*

Table 8. Bankruptcy risk portfolios and industry, age, and size allocation

Panel A. Bankruptcy risk portfolio and industry allocation

ZFC portfolio	High growth firms	Low growth firms	Total	High growth firms (%)
Low DR 1	359	85	444	0.81
2	293	129	422	0.69
3	279	232	511	0.55
4	206	290	496	0.42
5	166	287	453	0.37
6	104	270	374	0.28
7	92	207	299	0.31
8	62	112	174	0.36
9	58	59	117	0.50
High DR 10	33	8	41	0.80
Total	1,652	1,679	3,331	0.50

Note: The bankruptcy risk portfolios (Zmijewski (1984)'s financial condition (ZFC) scores) are based on all Compustat available firms for each year, including active and inactive firms. The high growth firms are defined as firms in the biotechnology (SIC 283), computer (SIC 357), high technology (SIC 360-369), and software (737). The low growth sample includes construction (SIC 160 and 170), light manufacturing (SIC 200-282, and 284-339), and heavy manufacturing (SIC 340-356), motor vehicles (SIC 371), and grocery stores (SIC 541).

Panel B. Bankruptcy risk portfolio and start-up firms

ZFC portfolio	Start-up firms	All other firms	Total	Start-up firms (%)
Low DR 1	127	404	531	0.24
2	75	461	536	0.14
3	66	554	620	0.11
4	81	524	605	0.13
5	50	505	555	0.09
6	53	399	452	0.12
7	61	316	377	0.16
8	30	196	226	0.13
9	27	107	134	0.20
High DR 10	7	36	43	0.16
Total	577	3,502	4,079	0.14

Note: The bankruptcy risk portfolios (Zmijewski (1984)'s financial condition (ZFC) scores) are based on all Compustat available firms for each year, including active and inactive firms. Start-up firms are defined as firm age less than 6 years, and 0 otherwise. Firm age is obtained from CRSP listing date.

Panel C. Bankruptcy risk portfolio and firm size

ZFC portfolio	Above median size	Below median size	Total	Above median size (%)
Low DR 1	138	393	531	0.26
2	182	354	536	0.34
3	279	341	620	0.45
4	312	293	605	0.52
5	334	221	555	0.60
6	289	163	452	0.64
7	288	89	377	0.76
8	152	74	226	0.67
9	56	78	134	0.42
High DR 10	9	34	43	0.21
Total	2,039	2,040	4,079	0.50

Note: The bankruptcy risk portfolios (Zmijewski (1984)'s financial condition (ZFC) scores) are based on all Compustat available firms for each year, including active and inactive firms. We use the median of sample firm size (4,079 obs.) because the sample firms are much larger than Compustat firms.

5.6 Large versus small size firms

Williams and Rao (2006) find that while Vega is positively related to managerial risk taking, larger firms have a moderating impact on this relation relative to smaller size firms. In order to investigate whether the main results are due to firm size effect, we separate the firms into large and small size subsamples based on firms' log (sales), and perform the same tests to the subsamples. Firms with more (less) than median sample size are defined as large (small) firms. Table 8 Panel C provides the relation between bankruptcy risk deciles and firm size. The low and high bankruptcy risk firms (portfolio 1 and 10) are smaller size than other deciles.
Simultaneous regression results for the high versus low bankruptcy risk (decile 8-10 versus deciles 1-7) for large and small firms show that CEO Vega has significant different impact on managerial risk taking for large size firms but not for small size firms.

5.7 Non-linear CEO ownership and risky investment R&D

Ghosh et al. (2007) find a non-linear relation between CEO stock ownership and R&D investment. Specifically, the authors divide CEO stock ownership levels into low (0, 5%), high (5%, 25%), and very high (>25%) range. They find that R&D investments are positively related to low CEO stock ownership, negatively related to high stock ownership, and insignificant for very high stock ownership.

In order to investigate whether the levels of CEO stock ownership impacts the results, the CEO-year observations with greater than 5% CEO stock ownership was dropped. This filter eliminates 386 observations, and left with high bankruptcy risk 381 observations and low and median bankruptcy risk 3,312 observations. The results are very similar to those reported in Table 5.

6. Conclusions

This study investigates the influence of equity-based compensation incentives on managerial risk taking choices for firms with and without risk shifting problem. Previous studies find that managers' equity-based compensation is different for firms with different bankruptcy risk, for example, Ortiz-Molina (2005) and Hayes and Hillegeist (2006). The current study expands our understanding of this topic by providing evidence on the effectiveness of managerial incentives on risk taking decisions for firms under bankruptcy risk. Using the Standard & Poor's Execucomp, Compustat industrial annual, and CRSP data over the period 1992-2004, we find that equity-based compensation impacts on managerial risk-taking are different for high bankruptcy risk firms relative to low bankruptcy risk firms. Specifically, Vega is found to have a lower impact on risk taking by high bankruptcy risk firms than by low bankruptcy risk firms, and Delta is found to have a higher impact on risk taking by high bankruptcy risk firms than low bankruptcy risk firms. These findings are consistent with the predictions that Delta, fully aligning the manager' and shareholders' conflict of interests, aggravates the risk shifting problem, and Vega, through the adjustment of exercise price, can be used to overcome the risk shifting problem. The finding is robust to alternative specifications such as with or without zero R&D investments, firm's industry allocation, firm age, and firm size. In addition, the study shows that the differential impacts disappear for firms with convertible debts, but still exists for firms with straight debt only. The results are consistent with the prediction that convertible debt can be used to mitigate the risk shifting problem.

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