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Executive Stock Options, Differential Risk-Taking Incentives, and Firm Value

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Abstract

The sensitivity of stock options' payoff to return volatility, or vega, provides risk-averse CEOs with an incentive to increase their firms' risk more by increasing systematic rather than idiosyncratic risk. This effect manifests because any increase in the firm's systematic risk can be hedged by a CEO who can trade the market portfolio. Consistent with this prediction, we find that vega gives CEOs incentives to increase their firms' total risk by increasing systematic risk but not idiosyncratic risk. Collectively, our results suggest that stock options might not always encourage managers to pursue projects that are primarily characterized by idiosyncratic risk when projects with systematic risk are available as an alternative.

Keywords

executive compensation, equity incentives, risk-taking incentives, systematic and idiosyncratic risk, hedging

Disciplines

Accounting

Executive Stock Options, Differential Risk-Taking Incentives, and Firm Value

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Abstract: The sensitivity of stock options' payoff to return volatility, or vega, provides risk-averse CEOs with an incentive to increase their firms' risk more by increasing systematic rather than idiosyncratic risk. This effect manifests because any increase in the firm's systematic risk can be hedged by a CEO who can trade the market portfolio. Consistent with this prediction, we find that vega gives CEOs incentives to increase their firms' total risk by increasing systematic risk but not idiosyncratic risk. Collectively, our results suggest that stock options might not always encourage managers to pursue projects that are primarily characterized by idiosyncratic risk when projects with systematic risk are available as an alternative.

Keywords: equity incentives; stock options; firm value; systematic and idiosyncratic risk; risk-taking incentives; executive compensation

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1. Introduction

This paper examines how executive stock options (ESOs) give chief executive officers (CEOs) differential incentives to alter their firms' systematic and idiosyncratic risk. Since ESOs give CEOs incentives to alter their firms' risk profile through both their sensitivity to stock return volatility, or vega, and their sensitivity to stock price, or delta, we examine both effects. Although prior empirical studies have examined the relationship between the incentives provided by ESOs and *total* firm risk (typically measured as the volatility of realized stock returns), recent theoretical research shows that it is important to distinguish between systematic and idiosyncratic risk when studying this relationship. In particular, vega gives risk-averse managers more of an incentive to increase total risk by increasing systematic rather than idiosyncratic risk, since, for a given level of vega, an increase in systematic risk always results in a greater increase in a CEO's subjective value of his or her stock-option portfolio than does an equivalent increase in idiosyncratic risk. This differential risk-taking incentive stems from CEOs' ability to hedge any unwanted increase in their firm's systematic risk by trading the market portfolio.[1] The above distinction between the two components of risk is important because it suggests that ESOs might not necessarily induce CEOs to undertake positive net present value (NPV) projects that are primarily characterized by idiosyncratic risk when projects with systematic risk are available as an alternative.

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[1] It is important to note that CEOs will still have these differential risk-taking incentives when they are precluded from trading the market portfolio. In this case, a CEO's only source of priced systematic risk is his or her firm-specific equity holdings. Therefore, a manager who seeks to increase the expected return of his or her equity portfolio by taking on more systematic risk can do so only by increasing the systematic risk of his or her firm. Since CEOs are generally presumed to be able to trade the market portfolio (Jin, 2002; Garvey and Milbourn, 2003), we focus on the hedging benefit of taking systematic rather than idiosyncratic risk.

Delta also gives managers incentives to alter the level of their firms' systematic and idiosyncratic risk, but, unlike with vega, the direction of the effect is ambiguous. On one hand, delta gives managers an incentive to reduce their firms' systematic and idiosyncratic risk by magnifying their exposure to their firm's risk. On the other hand, delta encourages managers to take risks that produce a sufficient increase in firm value or result in a transfer of wealth from creditors to shareholders (John and John, 1993).

Using a research design that accounts for the endogenous nature of the relationship between equity incentives and firms' risk profiles, we find evidence of a strong positive relationship between CEOs' equity portfolio vega and the level of both total and systematic risk. We also find that vega is unrelated to the level of idiosyncratic risk. Together, these findings suggest that vega gives managers incentives to increase total risk primarily through increasing systematic risk.

We also find evidence of a strong positive relationship between delta and the level of both systematic and idiosyncratic (and therefore total) risk, but no evidence of a differential relationship between delta and these two types of risk. The positive relationship between delta and idiosyncratic risk is particularly interesting, since, unlike with systematic risk, increasing idiosyncratic risk does not benefit managers either by improving their ability to hedge their exposure to their firms' risk or by increasing the expected return of their equity portfolio. This result, therefore, provides evidence on the risk-value tradeoff that managers face and suggests that investing in positive-NPV projects may require managers to increase their firms' idiosyncratic risk even though it cannot be hedged.

Collectively, our results suggest that vega may not necessarily elicit idiosyncratic risk-seeking from managers when opportunities to seek systematic risk are available. In a complementary analysis that speaks more directly to this issue, we examine how ESOs influence managers' acquisition decisions. In particular, we examine the subsample of firms that acquire another firm and compare the risk profile of the entity that results from combining the acquirer and the *actual* target with the risk profile of the entity that results from combining the acquirer and a *potential* target. This analysis therefore compares CEOs' actual risk-taking decisions with alternative decisions that the CEOs could have made. Our results for this analysis reveal that vega provides CEOs with incentives to acquire targets that increase their firms' systematic risk, but not idiosyncratic risk, relative to other acquisitions they could have made.

Collectively, our findings have important implications for compensation policy and firm value. The prior literature widely suggests that ESOs can be used to mitigate managers' aversion to investing in risky but positive-NPV projects (e.g., Haugen and Senbet, 1981; Smith and Stulz, 1985). To the extent that positive-NPV projects are primarily characterized by idiosyncratic rather than systematic risk, as suggested by our findings related to delta and prior empirical evidence, our results indicate that ESOs might not necessarily induce managers to pursue these projects.[2] Thus, managers' ability to hedge the systematic risk of their equity portfolio may limit the efficacy of ESOs to encourage managers to take idiosyncratic risk when systematic risk is available as an alternative.

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[2] For example, Cao, Simin, and Zhao (2008) and Vasselou and Abedjinou (2004) suggest that innovation and the pursuit of growth options manifest in the form of idiosyncratic volatility. Similarly, Pastor and Veronesi (2009) argue that the risk associated with new technologies is largely idiosyncratic until the technology is ultimately adopted on a large scale.

Our findings also raise the possibility that ESOs may induce managers to increase their firm's systematic risk, which they can hedge, even if it does not increase firm value. Doing so can adversely affect shareholders in two ways. First, there could be costs associated with managerial time and effort spent seeking systematic risk that does not necessarily increase firm value. Second, as Acharya and Bisin (2009) note, this approach may lead to excessive systematic risk in equity markets, which may, in turn, lead to reduced risk-sharing among investors and lower firm values.

Another important contribution of our study is that the specific nature of our research question and innovations in our research design allow us to better establish a causal relationship between managers' equity incentives and firm risk. There are two distinguishing features of our study in this regard.

First, because our hypothesis provides a differential prediction about the relationship between equity incentives and the systematic and idiosyncratic components of risk, concerns about correlated omitted variables that are inherent in research designs that examine the link between risk-taking incentives and *total* risk are mitigated.[3] In particular, our empirical findings suggest that if a correlated omitted variable were responsible for our results, it would have to induce a positive correlation between vega and systematic risk but not between vega and idiosyncratic risk. Although such a variable may exist, this requirement precludes otherwise likely candidates for omitted correlated

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[3] For example, if firms with more growth opportunities use ESOs in lieu of cash to compensate their CEOs, and these firms are more risky, then an observed relationship between ESOs and firm risk would not necessarily be causal. Similarly, if firms use ESOs to attract more risk-tolerant CEOs (since these CEOs will not demand as high of a risk premium for being compensated with risky ESOs), then an observed relationship between ESOs and firm risk might be a result of a willingness among more risk-tolerant CEOs to undertake risky projects, rather than because ESOs induce these CEOs to undertake more risk. To the extent that empirical tests cannot adequately control for growth opportunities, CEO risk tolerance, and other potentially correlated variables, the estimated relationship between ESOs and firm risk can be confounded.

variables (e.g., growth opportunities and executive risk tolerance) and thus enhances the credibility of our results.

Second, we develop an imputed measure of firm risk, which, compared with the realized volatility of returns, more directly captures the level and composition of risk that CEOs want to take. There are several reasons that realized return volatility might not necessarily capture a CEO's desired level and composition of firm risk. First, realized return volatility not only captures the outcome of a CEO's risk-taking decisions but also reflects a firm's disclosures, information trade in the firm's shares, and other features of the firm's information environment (Roll, 1988; Ross, 1989). Since we are interested in documenting the link between ESOs and CEOs' risk-taking decisions, this potentiality introduces the possibility of a spurious correlation between CEOs' equity incentives and measures of risk based on realized returns.[4] Second, because measures of risk based on future realized returns require a long time series to estimate, they do not necessarily reflect managers' anticipated risk profiles.[5,6]

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[4] For example, firms' disclosure practices, and hence their information environments, are known to be associated with their CEOs' incentive structure (Nagar, Nanda, and Wysocki, 2004). Further, a firm's information environment, in part, determines both realized stock return volatility and its components (Roll, 1988; Bushee and Noe, 2000). Together, these findings suggest that a measure of risk based on realized stock returns invites the possibility of a spurious correlation between CEO risk-taking incentives and firm risk.

[5] For example, a CEO may experience a change in his or her incentive structure in the future because of changes in the underlying contracting environment, or the firm may have a new CEO with different equity incentives. A measure of risk based on future realized returns may partly reflect the choice of assets (or risk profile) that is optimal given the current CEO's future incentives or the risk preferences of a different CEO, rather than the current CEO's choice of risk profile based on his or her current incentives.

[6] Some studies try to address this concern by examining a sample of firms that make a specific disclosure of expected future risk (e.g., Rajgopal and Shevlin, 2002) or by examining specific investments such as research and development and capital expenditures (e.g., Coles et al., 2006). One concern with the former approach is that confining the analysis to a small sample both limits the ability to generalize the results and, more importantly, precludes the efficient use of two-stage least squares to estimate the relationship, since the resulting coefficient estimates are biased in small samples (Bound, Jaeger, and Baker, 1995). Given the endogenous nature of equity incentives, it is crucial to have a large enough sample to allow for two-stage least squares estimation. Although the latter approach is feasible for large samples, it focuses only on a specific aspect of firm risk, rather than on aggregate risk. As we discuss later, our measure of firm risk is

We address this concern by developing an imputed measure of firm risk based on the portfolio of segments (or industries) in which a firm operates. Our measure views each industry as an operating asset with a risk profile that is relatively stable over time and can therefore be estimated using a long time series of industry-level returns. A firm is treated as a portfolio of industries the CEO chooses to achieve his or her desired level of systematic and idiosyncratic risk. The CEO can alter the firm's risk profile by investing in new industries, divesting from existing industries, or altering the weight of the firm's existing industry segments. We infer a CEO's desired risk profile from the risk profile of the portfolio of industries in which his or her firm operates. Since the industry-level risk profiles, upon which our firm-specific measures of risk are based, are less likely to be influenced by the specific features of firms' information environments, our measure of firms' risk profiles is more likely to reflect CEOs' anticipated level and composition of firm risk. We estimate our imputed measure of risk using firms' business-segment disclosures, which provide financial information on the portfolio of separately managed business units within the firm. Our approach for imputing firms' risk profiles is similar to that used by several studies on mutual funds that, instead of using actual fund returns, assess fund performance by examining the performance of the individual stocks the funds hold (e.g., Grinblatt and Titman, 1989; Grinblatt and Titman, 1993; Daniel, Grinblatt, Titman, and Wermers, 1997).

Another benefit of our imputed measure of risk is that it can be applied to a large sample of firms and is therefore amenable to empirical techniques to account for the endogenous relationship between equity incentives and firm risk. We exploit this benefit

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both available for a large sample of firms (and is therefore amendable to two-stage least squares estimation) and captures the aggregate risk profile of the firm.

of our measure through our use of an expansive sample and our use of two- and three-stage least squares (2SLS and 3SLS) estimation in our research design. This approach allows us not only to account for the endogenous relationship between equity incentives and firm risk, but also to test for a differential relationship between equity incentives and the systematic and idiosyncratic components of risk.

The next section of this paper discusses the relevant prior literature and develops our hypotheses. Section 3 describes our research design. Section 4 describes the manner in which we construct our main variables and the data we used in our analysis. We discuss our results in Section 5 and offer our conclusions in Section 6.

2. Prior literature and hypothesis development

2.1. Executive stock options and total risk

Risk-averse and undiversified managers who have most of their wealth tied to the value of their firm have an incentive to reject positive net present value projects that are sufficiently risky. A number of authors have suggested that because the expected payoff of an option is increasing in the volatility of the underlying stock's return, compensating risk-averse managers with stock options will encourage them to take risks (Haugen and Senbet, 1981; Smith and Stulz, 1985). However, subsequent studies (e.g., Lambert, Larcker, and Verrecchia, 1991; Carpenter, 2000; Ross, 2004; Lewellen, 2006) point out that executives who cannot sell or otherwise hedge the risk associated with their options will not value them at their market value but will instead value them subjectively through the lens of their own preferences. Consequently, granting ESOs to a risk-averse executive may not necessarily increase that executive's appetite for risk. These studies note that stock options not only increase the convexity of a manager's payoff by increasing the sensitivity of his or her wealth to firm risk, or vega, but also increase the sensitivity of his or her wealth to changes in stock price, or delta. And although the increase in vega unambiguously induces a manager to take more risks, the corresponding increase in delta magnifies the manager's aversion to firm risk because a given change in stock price has a larger impact on the value of the manager's firm-specific portfolio. Thus, the net effect of greater option compensation on managerial risk-taking is ambiguous.

These theories motivated a number of early empirical studies, which generally found a positive relationship between stock options and various measures of firm risk (e.g., Agrawal and Mandelker, 1987; Defusco, Johnson, and Zorn, 1990; Tufano, 1996; Schrand and Unal, 1998; Guay, 1999; Rajgopal and Shevlin, 2002). More recent studies (e.g., Coles et al., 2006; Low, 2009) acknowledge the different theoretical predictions regarding the relationship between vega and delta and firm risk, and thus account for them separately in their empirical specifications. Although all of these studies document a positive relationship between vega and firm risk, they provide mixed evidence on the relationship between delta and firm risk.[7] In contrast to these studies, however, Lewellen (2006) finds that options actually discourage managerial risk-taking for empirically plausible parameter values in a certainty-equivalent framework.

Coles et al. (2006), Low (2009), and others note that one possible explanation for the mixed empirical evidence on the relationship between stock options and firm risk is

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[7] For example, Coles et al. (2006) report mixed results regarding the effect of delta for various measures of risk-taking. On one hand, they find that delta is positively associated with firm focus and return volatility, an outcome that suggests that delta encourages risk-taking. On the other hand, they find that delta makes managers more risk-averse by encouraging them to increase capital expenditures, decrease R&D expenditures, and decrease leverage. Low (2009) also concludes that her evidence on the relationship between delta and managerial risk-taking is inconclusive.

that because equity incentives and firm risk are endogenously related, the relationship is difficult to empirically identify. Another possible explanation is that the net effect of ESOs on risk-taking depends on the empirical values of firm risk and CEO risk aversion, since, for certain combinations, stock options can provide an incentive to *reduce* total risk (Lambert et al., 1991; Carpenter, 2000; Ross, 2004). As we discuss further below, one advantage of examining the effect of ESOs on the two components of total risk separately is that ESOs motivate managers to increase systematic risk for every combination of firm risk and CEO risk aversion, and that is not necessarily the case for idiosyncratic risk. This result allows us to construct empirical tests of the relationship between ESOs and risk-taking that are less likely to be misspecified as a result of this potentially non-monotonic relationship that exists for total risk.

2.2. Executive stock options and the components of risk

Several recent theoretical studies (e.g., Tian, 2004; Henderson, 2005; Duan and Wei, 2005) suggest that it is important to distinguish between systematic and idiosyncratic risk when studying the relationship between ESOs and firm risk. These studies show that for a fixed level of total risk, increasing the *proportion* of systematic risk unambiguously increases the subjective value of the stock-option holdings of a risk-averse manager who can trade the market portfolio, because a higher proportion of systematic risk implies that a higher proportion of the firm's total risk (and therefore a higher proportion of the risk associated with the manager's firm-specific holdings) is correlated with the market and can therefore be hedged.

To further extend this intuition and to facilitate our hypothesis development, we develop a numerical model that examines the effects of vega on a risk-averse CEO's incentives to alter systematic and idiosyncratic risk, while holding the effect of delta and total wealth constant. Specifically, we compare several portfolios of stock options, shares, and cash by simultaneously (1) adding options to the CEO's portfolio to increase its vega, (2) removing shares of stock from the CEO's portfolio to keep its delta constant, and (3) adding fixed wealth to keep the value of the CEO's entire holdings (i.e., stock, options, and cash) constant. The Appendix provides details that underlie the numerical model that we used to compute the subjective value of these portfolios.

Fig. 1 illustrates the effect of increasing vega on a CEO's incentives to alter his or her firm's risk profile by providing plots of the percentage change in the CEO's certainty equivalent of his or her equity portfolio for a given change in either systematic or idiosyncratic (and therefore total) risk for different levels of vega for four different levels of CEO risk aversion. Two noteworthy features emerge from this figure. First, consistent with the intuition from the theoretical literature on the relationship between ESOs and total risk, Fig. 1 shows that increasing vega while holding delta and total wealth constant always results in a larger percentage increase in a CEO's certainty equivalent of his or her equity portfolio for both types of risk. Thus, vega provides managers with incentives to increase total risk, regardless of whether the increase comes from systematic or idiosyncratic risk. This observation leads to our first hypothesis (stated in alternative form), which predicts a positive relationship between vega and total, systematic, and idiosyncratic risk.

> *H1: Vega is positively associated with total risk and its systematic and idiosyncratic components.*

Second, Fig. 1 shows that for a given level of vega, an increase in systematic risk always results in a greater increase in the CEO's certainty equivalent of his or her equity portfolio than does an equivalent increase in idiosyncratic risk. This effect manifests because CEOs can hedge any unwanted increase in their firm's systematic risk by trading the market portfolio. This finding leads to our second hypothesis (stated in alterative form), which predicts that the positive relationship between total risk and vega is driven more by an increase in systematic risk than by an increase in idiosyncratic risk.

> *H2: A larger portion of the increase in total risk caused by vega comes from an increase in systematic risk than from an increase in idiosyncratic risk.*

Our first hypothesis is similar to the one tested in previous empirical studies (e.g., Guay, 1999; Rajgopal and Shevlin, 2002; Coles et al., 2006; Low, 2009) and follows from the theoretical literature on the relationship between ESOs and total risk, which predicts a positive relationship between vega and any kind of risk. Our second hypothesis is refined to take into account the distinction between systematic and idiosyncratic risk and their differential effects on managers' subjective values of their equity portfolios. This distinction is important for two reasons. First, it raises the possibility that ESOs might not necessarily give CEOs incentives to pursue projects that are primarily characterized by idiosyncratic risk when projects with systematic risk are available as an alternative. Second, because the differential nature of risk-taking incentives mitigates traditional concerns about correlated omitted variables, we can better establish a causal relationship between managers' risk-taking incentives and firm risk.

It is also important to note that our second hypothesis about the increase in risk coming primarily from systematic risk is more robust than is the more general prediction that stock options provide incentives to increase firm risk. Unlike an increase in total risk, which can result in a *decrease* in an executive's subjective value of his or her options for certain combinations of risk aversion and firm risk (as noted by Lambert et al., 1991, Carpenter, 2000, and Ross, 2004), an increase in systematic risk *always* increases a risk-averse executive's subjective value of his or her options for *every* combination of risk aversion and total firm risk, because it can be hedged.

In addition to providing risk-taking incentives from vega, stock options also give managers incentives to change their firms' risk profile through delta. However, unlike the effect of vega, the effect of delta on the level of total risk and its systematic and idiosyncratic components is theoretically ambiguous. On one hand, delta gives managers an incentive to reduce total risk and its components by magnifying the concavity of their utility functions. On the other hand, there are two reasons delta could induce managers to increase the level of risk. First, delta gives managers an incentive to increase the market value of their firms' equity by investing in positive net present value projects, which may, in turn, require them to increase idiosyncratic and/or systematic risk. Thus, if the manager's increase in subjective value that results from the increase in market value exceeds the decrease in subjective value that results from the associated increase in risk, then delta may be positively associated with total risk and its systematic and idiosyncratic components. Second, for levered firms, delta could provide managers with incentives to invest in riskier projects that benefit shareholders at the expense of their firms' creditors (John and John, 1993). Thus, the effect of delta on firms' total risk and its separate components is ambiguous, and we consider it to be an empirical issue.

3. Research design

3.1. Risk profile of the firm

To test our hypotheses, we estimate a series of equations in which we model the level of total firm risk and its systematic and idiosyncratic components. The equations that capture firms' risk profiles are as follows.

$$Total\ Risk_{t+1} = \beta_0 + \beta_1 Vega_t + \beta_2 Delta_t + \sum_i \beta_i Control_{i,t} + \varepsilon_{t+1} \quad (1)$$

$$Systematic\ Risk_{t+1} = \gamma_0 + \gamma_1 Vega_t + \gamma_2 Delta_t + \sum_i \gamma_i Control_{i,t} + \varepsilon_{t+1} \quad (2)$$

$$Idiosyncratic\ Risk_{t+1} = \delta_0 + \delta_1 Vega_t + \delta_2 Delta_t + \sum \delta_i Control_{i,t} + \varepsilon_{t+1} \quad (3)$$

Our first hypothesis that vega encourages CEOs to increase the level of total risk and its systematic and idiosyncratic components predicts a positive coefficient on vega in Eq. (1) – (3) (i.e., $\beta_1 > 0$, $\gamma_1 > 0$, and $\delta_1 > 0$). We formally test our second hypothesis that the increase in total risk induced by vega comes more from systematic than from idiosyncratic risk by estimating the systematic- and idiosyncratic-risk equations (i.e., Eq. (2) and Eq. (3)) simultaneously and predict that the coefficient on vega in Eq. (2) is both positive and larger than the coefficient on vega in Eq. (3) (i.e., $\gamma_1 > 0$ and $\gamma_1 > \delta_1$). Finally, since the direction of the relationship between delta and total, systematic, and idiosyncratic risk is theoretically ambiguous, we do not supply a prediction on the sign of delta in any of the risk-profile equations.

Our choice of control variables in the risk-profile equations is based primarily on prior literature. First, we include firm size, measured as the natural logarithm of total annual sales, since prior literature (e.g., Guay, 1999; Coles et al., 2006; Low, 2009) has documented a negative relationship between size and firm risk. Next, we include leverage, measured as the ratio of long-term debt to total assets. On one hand, higher leverage provides managers with greater incentives to transfer wealth from bondholders to shareholders (Leland, 1998), a result that predicts a positive relationship between leverage and total risk and each of its separate components. On the other hand, a number of studies (e.g., Friend and Lang, 1998; Lewellen, 2006) have argued and found evidence consistent with the hypothesis that more risky firms face a higher probability of financial distress and therefore should have less leverage. This finding also suggests that firms may offset the increased risk of financial distress that accompanies any increase in leverage by reducing their operating risk. Given these conflicting hypotheses and the conflicting evidence in prior studies, we do not supply a prediction on the sign of leverage in any of the risk-profile equations.

Next, we expect managers of firms with larger investment-opportunity sets and more growth options to take more risk than would managers of firms with smaller investment-opportunity sets and fewer growth options (Guay, 1999). We therefore include the book-to-market ratio, the prior period's sales growth, and net investment in property, plant, and equipment scaled by total assets to capture variation in firms' investment and growth opportunities.[8] Following Berger et al. (1997) and Guay (1999), we also include the logarithm of CEO tenure and CEO cash compensation to proxy for

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[8] Although prior studies frequently use research-and-development expense (R&D) and capital expenditures (capex) as proxies for a firm's growth opportunities, we do not include these variables in our risk profile specifications. If managers alter R&D and capex to achieve their desired level of systematic and idiosyncratic risk, then including R&D and capex as controls may eliminate the differential risk-taking effect that we are interested in and thus reduce the power of our empirical tests. Previous literature provides evidence to support this concern. In particular, Lev and Sougiannis (1996) document a significant intertemporal relationship between capitalized R&D expense and subsequent stock returns. They interpret this finding as either a mispricing of the shares of R&D-intensive companies or as compensation for an extra market-risk factor associated with R&D. Ho, Xu, and Yap (2004) argue that the higher systematic risk that accompanies R&D-intensive companies can explain this anomaly. In our sample, R&D exhibits a relatively high (Pearson) correlation of 0.328 with systematic risk, and a negative correlation of -0.111 with idiosyncratic risk; and capex has a correlation of -0.109 and 0.331, with systematic and idiosyncratic risk, respectively. In addition, Coles et al. (2006) provide evidence of a positive causal relationship between risk-taking incentives and R&D and a negative causal relationship between risk-taking incentive and capex. Thus, the findings from Coles et al. (2006), together with the observed correlation structure in our sample, are consistent with managers' use of R&D and capex as discretionary tools to take systematic and idiosyncratic risk.

the degree of CEO risk aversion. Although our proxies for investment and growth opportunities and managerial risk aversion are expected to capture the underlying constructs to some degree, they are likely to be measured with error. In addition, prior literature generally does not predict a sign for these variables, so we, too, do not supply a prediction.

A final issue is how to include industry controls, since the level of total, systematic, and idiosyncratic risk could vary systematically across industries in a way that the other control variables do not necessarily capture. Since our research design views each firm as a portfolio of operating segments with time-varying weights that the CEO selects, it is not clear what the appropriate industry would be for a multisegment firm. We follow two complementary approaches to address this issue. First, we estimate the equations without industry controls. This approach assumes that the remaining control variables in the model adequately capture the determinants of firms' risk profiles, absent the effect of executives' equity incentives. Second, we follow Denis et al. (1997) and include industry indicators for all (two-digit SIC) industries in which the firm operates. This approach treats a firm as a portfolio of segments that potentially operates across multiple industries.

3.2. Endogenous nature of equity incentives

In addition to ESOs influencing managers' risk-taking behavior, causality is also likely to run in the other direction. That is, when designing compensation contracts, boards are likely to anticipate the effects of CEOs' equity incentives on their decisions and will incorporate this expectation into the contract design, so these variables will be jointly determined. We account for the endogenous nature of compensation contracts in our research design using instrumental variables and estimate the risk-profile equations using two- and three-stage least squares.

Our instruments for equity incentives (i.e., vega and delta) are based on the determinants identified by prior research that should not have a direct effect on the risk profile of the firm, but that should have an indirect relationship through their effect on equity incentives and the other control variables. Core and Guay (1999) find that cash-constrained firms tend to use restricted stock and stock options as substitutes for cash compensation. Alternatively, firms with greater cash balances are more likely to have greater agency problems (Jensen, 1986; Stulz, 1990), which equity incentives can mitigate (Garvey, 1997). Although the sign of their relationship with equity incentives is ambiguous, cash constraints are a candidate for an instrument because there is no obvious reason cash-constrained firms would have systematically different *ex ante* risk profiles than would firms that are not cash-constrained. Thus, our first instrument for equity incentives is the amount of cash and short-term investments scaled by assets, which captures the short-term availability of cash to make compensation payments (Core and Guay, 1999).

Our second instrument for equity incentives is a firm's marginal tax rate. Core and Guay (1999) argue that when future corporate tax rates are expected to be higher, the future tax deduction from deferred compensation becomes more valuable relative to the immediate tax deduction associated with cash compensation. Therefore, *ceteris paribus*, equity-based compensation is expected to be less costly for firms with lower marginal tax rates, and we expect a negative relationship between equity incentives and a firm's marginal tax rate. We follow Core and Guay (1999) and proxy for a firm's marginal tax rate with an indicator that is equal to one if a firm has a tax-loss carry-forward in any of the past three years and zero otherwise.

Our final set of instruments is based on the firm's past performance. If firms reward managers for their past performance with restricted stock and options, then we expect past performance to be correlated with equity incentives. However, there is no obvious reason for an association between past measures of a firm's performance and a firm's current risk profile, other than the effect through equity incentives and the control variables such as leverage.[9] Thus, we use the previous two years' stock returns ($Return_t$ and $Return_{t-1}$) and the previous year's return on assets (*ROA*) as our final instruments for CEO equity incentives.

As with any study that uses instrumental variables, the validity of the resulting estimates relies on the validity of the exclusion restrictions. Two unique features of our hypotheses and research design help mitigate concerns about the efficacy of our instruments. First, the differential nature of our predictions about the effect of vega on systematic and idiosyncratic risk mitigates typical endogeneity concerns related to correlated omitted variables. Specifically, since there is no obvious reason why the most likely candidates for correlated omitted variables in a risk-taking setting (e.g., firms' growth opportunities and CEO risk tolerance) would have a differential relationship with the firms' systematic and idiosyncratic risk, the test of our second hypothesis is less likely to be biased from any correlated omitted variables of this type. Second, we test the

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[9] An empirical regularity documented in the literature is the negative relationship between stock returns and future return volatility. Black (1976) and subsequent authors (e.g., Christie, 1982) have advanced the so-called "leverage effect" view to explain this phenomenon, whereby negative stock returns reduce the value of the firm's equity while the amount of debt remains fixed, a situation that results in a higher volatility of equity returns. The existence of this effect does not invalidate our use of prior returns as an instrument for leverage, because the effect of prior stock price performance on volatility, or risk, is precisely through its effect on a firm's leverage, which is included as a control variable in the risk-profile equations.

validity of our instruments using Hansen's (1982) test of overidentifying restrictions and report the associated *J*-statistics. A *J*-statistic that is significantly different from zero indicates a violation of at least one of the maintained assumptions of the test, including the assumption that the instruments are exogenous. As we discuss further below, we find that the *J*-statistic is not statistically different from zero in most of our specifications, a result that further supports the validity of our instruments.

Implementation of two-stage least squares (2SLS) requires estimating the predicted values of the endogenous variables (i.e., vega and delta) by regressing them on the instruments and the other exogenous controls in the first stage. The predicted values of the endogenous variables are then used in the second stage to estimate the risk-profile equations. We interpret the first-stage regressions of equity incentives on the instruments and the other exogenous controls as contract-design equations, since many of these variables have also been identified as determinants of equity incentives in their own right.

First, we expect firm size to capture variation in the degree of talent and wealth across CEOs. Prior literature has argued that larger firms require more talented CEOs and that CEOs of larger firms tend to be more wealthy (Smith and Watts, 1992; Core and Guay, 1999). We therefore predict a positive relationship between firm size and the level of equity incentives. Next, we expect the consequences of excessive managerial risk aversion (i.e., rejecting risky but positive net present value projects) to be more costly to shareholders of firms with more investment opportunities. We also expect that it is more difficult to monitor managers of firms with greater investment opportunities, so equity incentives will be used as a substitute mechanism for mitigating agency costs in these firms (Smith and Watts, 1992). We therefore expect both types of equity incentives to be negatively associated with the book-to-market ratio and positively associated with the previous year's sales growth.

We expect cash compensation to proxy for CEO risk aversion. Guay (1999) argues that CEOs with higher cash compensation are better able to diversify their portfolio and will therefore be less risk-averse. Accordingly, CEOs with higher cash pay should also have higher equity incentives to counteract this risk aversion. Thus, we predict a positive relationship between the amount of cash compensation and the level of equity incentives.[10] Finally, we expect CEO tenure to capture both CEO experience (Gibbons and Murphy, 1992) and the degree to which there might be horizon problems as a result of an anticipated departure (Dechow and Sloan, 1991). Consistent with prior literature, we predict a positive relationship between CEO tenure and the level of equity incentives.

3.3. Endogenous nature of leverage

Another concern with the risk-profile equations is that leverage is also likely to be endogenously determined. This concern is particularly acute in any study that examines CEO risk-taking incentives, since both a firm's capital structure and the risk-taking incentives of its CEO are likely to be jointly determined to produce the desired risk profile (Coles et al., 2006; Lewellen, 2006). We therefore adapt our research design to also account for the endogenous nature of firm leverage. We do so by using the firm's recent performance, measured as the previous two years' stock returns and the previous year's return on assets as instruments for leverage. These measures of firm performance should exhibit a positive relationship with a firm's total assets, which is the denominator

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[10] Since cash compensation is likely to be decided at the same time as the optimal level of equity incentives, it is possible that cash compensation is also endogenous. We therefore re-estimate our analyses excluding cash compensation and find that our reported results are virtually unchanged.

of our measure of leverage, and are therefore relevant instruments. As we previously discussed, there is no obvious reason to expect a direct relationship between our measures of a firm's past performance and its current risk profile, which suggests that these are valid instruments.

4. Variable measurement and sample selection

4.1. Measurement of firm risk

Most studies measure total risk as the volatility of future returns and disaggregate it into its systematic and idiosyncratic components using either the CAPM or some other affine asset-pricing model (e.g., the Fama and French, 1993 model). This approach can be problematic when studying the effect of CEO risk-taking incentives because future realized volatility reflects not only the outcome of a CEO's risk-taking decisions, but also the firm's disclosures, information trade in the firm's shares, and other features of the firm's information environment. In addition, a CEO may experience a change in his or her incentive structure in the future because of changes in the underlying contracting environment, or the firm may have a new CEO with different risk preferences. A measure of risk based on future realized returns would not necessarily reflect the current CEO's risk preferences based on his or her current incentive structure and may instead introduce a spurious correlation between risk-taking incentives and firm risk. We therefore construct imputed measures of the systematic and idiosyncratic risk that the CEO would have anticipated using information about the current portfolio of segments in which the firm operates.[11] A firm is considered as a portfolio of industries the CEO chooses to achieve his or her desired level of systematic and idiosyncratic risk. The CEO can alter the firm's risk profile by investing in new industries, divesting from existing industries, and altering the weight of the firm's existing industry segments.[12]

To construct our measures of firm risk, we gather information about the operating segments and the book value of assets in those segments from the Compustat Industry Segment Database, where industry segments are defined at the two-digit SIC level.[13] We let n_j denote the number of industry segments in which firm j operates at the end of the fiscal year, A^i_j denote the book value of assets of the i^{th} segment of firm j, and A_j denote the total book value of firm j. Next we define r^i_t as the month t return for the ith industry segment, calculated as a value weighted-average of the monthly returns of all firms in the Compustat database that operate exclusively in segment i at the end of the fiscal year, and $r_{m,t}$ as the monthly return of the market portfolio for month t. We compute r^i_t only for those segment years for which there are at least three firms that operate solely in industry

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[11] In untabulated analyses that use the volatility of future realized returns rather than our imputed measure of firm risk, we find that all of our primary results continue to hold, although sometimes with diminished statistical significance.

[12] An alternative mechanism by which managers can alter the level and composition of their exposure to their firm's risk is through personally hedging their exposure to idiosyncratic risk. However, this is expected to be a second-order effect, since firms severely restrict managers' ability to directly hedge idiosyncratic risk through financial transactions. Recent empirical evidence suggests that the incidence of hedging firm-specific risk among managers is very low. For example, Jagolinzer, Matsunaga, and Yeung (2007) find that insiders initiated only 203 prepaid variable forward (PVF) transactions, which allow insiders to hedge firm-specific risk, between August 8, 1996, and June 30, 2004. Similarly, Bettis, Bizjak, and Lemmon (2001) find only 87 zero-cost collar transactions and two equity-swap transactions by insiders at 65 firms from January 1996 through December 1998. Finally, Bettis, Coles, and Lemmon (2000) find that a majority of the firms in their sample have policies restricting insider trading.

[13] *Statement of Financial Accounting Standards* No. 131 ("Disclosures about Segments of an Enterprise and Related Information," 1997) adopts the "management approach" to identifying and reporting operating segments on the basis of how management segments the company for making operating decisions. In general, under this approach, an operating segment is a component of a company (1) that engages in activities for which it earns revenues and expenses, (2) whose results undergo regular review to assess performance and to allocate resources within the firm, and (3) for which financial performance is available based on the firm's financial-reporting system.

i. Finally, we define $r_{j,t}$ as the *imputed* monthly return for firm *j* at time *t* according to the following equation:

$$r_{j,t} = \sum_{i=1}^{n_j} \frac{A_j^i}{A_j} r_t^i \tag{4}$$

We calculate the variance of imputed monthly returns, $r_{j,t}$, over the previous 60 months, and require at least 20 months, as our measure of total risk. We then disaggregate total risk into its systematic and idiosyncratic components by regressing imputed monthly returns on the Fama and French (1993) factors as follows.

$$r_{j,t} = \beta_{0,j} + \beta_{1,j} r_{MKTRF,t} + \beta_2 r_{SMB,t} + \beta_3 r_{HML,t} + e_{j,t} \tag{5}$$

This equation is estimated for each firm at the beginning of each year using the returns imputed from Eq. (5).[14] We then calculate our measure of systematic risk as the square root of the explained variance and our measure of idiosyncratic risk as the square root of the unexplained variance. We use these adjusted measures of systematic and idiosyncratic risk rather than their more common counterparts (i.e., $\beta_{1,j}$) as a measure of systematic risk because our approach makes both measures more comparable in terms of scale. This comparability, in turn, allows for a more direct test of our second hypothesis by comparing the estimated coefficients on vega and delta across Eq. (2) and Eq. (3).

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[14] Note that the book-value weights of the segments in which a firm operates remain constant during the period in which we estimate Eq. (5) for a particular fiscal year. However, these weights can and do vary across fiscal years. For example, consider a firm that operates in two-digit SIC segments A and B at the end of 2005 with book-value weights of $x_{A,\ 2005}$ and $x_{B,\ 2005}$, respectively. Let r_t^A and r_t^B denote the value-weighted return during month *t* of all of the single-segment firms that operate exclusively in segment A and segment B, respectively, during month *t*. To compute our risk measures at the end of 2005, we first obtain r_t^A and r_t^B for each of the 60 months before December 2005. The firm's imputed monthly returns for each month during the estimation window are then computed as $r_t = (x_{A,\ 2005} * r_t^A) + (x_{B,\ 2005} * r_t^B)$, where the weights x_A and x_B are held constant during the entire estimation window. Finally, these imputed monthly returns are used to estimate Eq. (5) to obtain our measures of the firm's risk profile at the end of 2005. To further illustrate, suppose that at the end of 2006 the firm continues to operate in segments A and B but with book value weights of $x_{A,\ 2006}$ and $x_{B,\ 2006}$, respectively. We would obtain our measures of the firm's risk profile at the end of 2006 by repeating the above calculation with the new weights, $x_{A,\ 2006}$ and $x_{B,\ 2006}$.

Total risk is measured as the standard deviation of imputed monthly returns. Because of the highly skewed distributions of these risk measures, we use the natural logarithm of the measures when estimating the risk-profile equations.

4.2. Measurement of equity incentives

We follow prior literature (e.g., Guay, 1999; Coles et al., 2006; Low, 2009) and measure executives' equity portfolio vega as the change in the risk-neutral (i.e., Black-Scholes) value of the executive's option portfolio for a 0.01 change in the standard deviation of the underlying stock returns.[15] Similarly, we follow prior literature (e.g., Core and Guay, 1999; Coles et al., 2006) and measure executives' equity portfolio delta as the change in the risk-neutral value of the executive's equity portfolio for a 1% change in the price of the underlying stock.[16,17] Since both delta and vega are highly skewed, we follow prior literature and use the natural logarithm of both variables in our analysis.

4.3. Sample selection

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[15] Guay (1999) shows that the vega from shares of stock is insignificant for all but the most financially distressed firms, where equity becomes more like an at-the-money option. Consequently, the vega from a CEO's option portfolio is several orders of magnitude larger than the vega from the CEO's stock portfolio. Following prior literature (e.g., Coles et al., 2006; Low, 2009), we ignore vega from stock holdings and measure risk-taking incentives as the vega of the CEO's option portfolio.

[16] The parameters of the Black-Scholes formula are calculated as follows. Annualized volatility is calculated using continuously compounded monthly returns over the previous 60 months, with a minimum of 12 months of returns, and winsorized at the fifth and 95th percentiles. If the stock has traded for less than one year, we use the imputed average volatility of the firms in the S&P 1500. The risk-free rate is calculated using the interpolated interest rate on a Treasury note with the same maturity (to the closest month) as the remaining life of the option, multiplied by 0.70 to account for the prevalence of early exercise. Dividend yield is calculated as the dividends paid over the past 12 months scaled by the stock price at the beginning of the month. This is essentially the same method Core and Guay (2002) describe.

[17] An alternative to the dollar-holdings measure of the incentive to increase stock price is the fractional-holdings measure, calculated as the change in the (risk-neutral) value of the executive's equity portfolio for a $1,000 change in firm value (Jensen and Murphy, 1990). Baker and Hall (2004) and Core, Guay, and Larcker (2003) discuss how the suitability of each measure is context-specific and depends on how the CEO's actions affect firm value. When the CEO's actions affect the dollar returns of the firm (e.g., consuming perquisites), the fractional holdings are the appropriate measure of incentives. When the CEO's actions affect the percentage returns of the firm (e.g., decisions about corporate strategy), the dollar-holdings measure is the appropriate measure of CEO incentives. Since we are concerned about strategic actions that affect the firm's risk profile, we rely on the dollar-holdings measure of incentives.

Our sample is constructed from four primary data sources. First, we obtain data on CEO compensation and equity portfolio holdings from the ExecuComp database. Second, we obtain data on the segments in which our sample firms operate from the Compustat Industry Segment Database. Third, we gather stock return and Treasury bond yield data from CRSP. Finally, we gather financial statement information from Compustat. Consistent with prior literature, we exclude financial service firms and utilities.

Table 1 presents descriptive statistics for the primary variables in our analysis. Our final sample consists of 13,233 firm-year observations from 1992 to 2007, for which the required data are available. To ensure that outliers do not drive our results, we winsorize vega, delta, leverage, book-to-market ratio, cash compensation, and PP&E at the first and 99th percentiles. The mean (median) systematic and idiosyncratic risk of our sample firm is 0.06 and 0.04 (0.05 and 0.04), respectively, and both variables have a relatively symmetric distribution. Table 1 also shows that our sample consists of relatively large firms with mean and median annual sales of roughly $4.427 billion and $1.091 billion, respectively. These results are consistent with previous studies that use ExecuComp.

Table 1 also reveals that the CEOs in our sample have relatively large portfolio equity incentives. In particular, a 1% increase in stock price results in a mean (median) increase in the risk-neutral value of their equity portfolio of roughly $718,000 ($207,000). We also find that a 0.01 increase in the standard deviation of returns results in a mean and median increase in the risk-neutral option portfolio value of roughly $100,000 and $38,000, respectively. Consistent with prior research (e.g., Core and Guay, 1999; Coles et al., 2006), both variables are highly skewed, but their log-transformed counterparts are more normally distributed. Finally, the mean (and, to a lesser extent, median) equity-incentive values are considerably larger than are the values reported in previous studies, such as those from Core and Guay (1999), Rajgopal and Shevlin (2002), and Coles et al. (2006). This difference is likely due to our use of a more recent sample period, during which there was an increase in the use of equity-based compensation and growth in the magnitude of executive compensation packages.

5. Results

5.1. Firm risk profile with endogenous incentive contracts

We present our first set of results in Table 2, where we treat CEO incentives as endogenous and estimate the contract-design and risk-profile equations using 2SLS. Panel A presents the first-stage contract design equations for both vega and delta, respectively. The first two columns present results when industry indicators are excluded from the specification, and the second two columns present results when industry indicators are included.

The coefficients in these equations generally have the predicted sign and are consistent with findings in prior research. Specifically, we find a positive and significant coefficient on the natural logarithm of sales in both the vega and delta equations, which indicates that CEOs of larger firms have more of both types of equity incentives. We also find a strong negative relationship between book-to-market and both vega and delta, which indicates that the CEOs of firms with more growth opportunities have more equity incentives. Finally, we find a strong positive relationship between cash compensation and both vega and delta.

The instruments excluded from the second-stage risk regressions but included in the contract-design equations are *Cash*, *TaxLoss*, *ROA*, $Return_t$, and $Return_{t-1}$. We find that in both contract-design equations, these instruments are generally of the predicted sign and are statistically significant, which suggests that these are valid instruments. For example, we find a positive and significant coefficient on *Cash*, which suggests that firms with larger cash balances use equity incentives to mitigate agency problems (Garvey, 1997). The partial *F*-statistic is highly significant in all four equations, which indicates that, collectively, the instruments provide a significant degree of incremental explanatory power and, thus, that our results should not be susceptible to biases from weak instruments. This assessment is further confirmed by the partial R^2 of 2.1% (1.4%) and 1.3% (1.5%) in the vega and delta equations, respectively, when industry indicators are excluded (included).

Panel B of Table 2 presents estimates of the risk-profile equations from the second-stage regression. The first two columns model the level of total risk. Consistent with prior literature (e.g., Guay, 1999; Rajgopal and Shevlin, 2002; Coles et al., 2006; Low, 2009), we find that the coefficient on vega is positive and significant, both without and with industry controls, with coefficients of 0.115 and 0.079, respectively, and *t*-statistics of 2.86 and 3.81, respectively. In the third and fourth columns, in which we model the level of systematic risk, we find that the coefficient on vega is positive and significant both without and with industry controls, with coefficients of 0.149 and 0.125, respectively, and *t*-statistics of 3.23 and 4.43, respectively. In the next two columns, we find that vega exhibits no statistical relationship with the level of idiosyncratic risk either with or without industry controls. The results in the total and systematic risk equations are consistent with our first hypothesis, which predicts a positive relationship between vega and total risk and its systematic and idiosyncratic components. However, we do not find a significant relationship between vega and idiosyncratic risk. One possible explanation for this finding is that vega does not induce managers to seek idiosyncratic risk when enough opportunities to increase systematic risk are available, possibly because an increase in systematic risk always results in a greater increase in managers' subjective value of his or her option portfolio than does an equivalent increase in idiosyncratic risk.

Our second hypothesis predicts that a larger proportion of the increase in total risk induced by vega comes from systematic than from idiosyncratic risk. A formal test of this hypothesis involves comparing the magnitude of the coefficients on systematic and idiosyncratic risk. Although the results in Panel B of Table 2 suggest that the coefficient on vega is larger than its counterpart in the idiosyncratic-risk equation, we cannot formally compare coefficients across these equations since they have been estimated independently of each other. We therefore simultaneously estimate the systematic- and idiosyncratic-risk equations using three-stage least squares (3SLS), with the results presented in Table 3. We find that the coefficient on vega in the systematic-risk equation is significantly greater than the coefficient on vega in the idiosyncratic-risk equation in both the specification that excludes and includes industry controls (*z*-statistics of 3.41 and 4.36, respectively). These results are consistent with our second hypothesis and indicate that vega gives CEOs stronger incentives to increase systematic risk than to increase idiosyncratic risk.

We also find a positive and significant relationship between delta and total risk and its systematic and idiosyncratic components both with and without industry controls in the 2SLS specification in Panel B of Table 2. These results suggest that increasing both systematic risk and idiosyncratic risk leads to an increase in equity value. The positive relationship between delta and idiosyncratic risk is particularly noteworthy since, unlike systematic risk, increasing idiosyncratic risk does not benefit a manager either through an improved ability to hedge his or her firm-specific wealth, or by increasing the expected return of his or her equity portfolio. This result speaks to the risk-value tradeoff managers face and suggests that investing in positive-NPV projects may require managers to increase unhedgeable idiosyncratic risk. In other words, for the firms in our sample, higher incentives to increase equity value (by investing in positive-NPV projects) provided by delta, on average, outweighs CEOs' increased aversion to idiosyncratic risk that results from higher delta. Finally, in Table 3 we find that the coefficient on delta in the systematic risk equation is not significantly different from the coefficient on delta in the idiosyncratic-risk equation in either specification, which suggests that delta gives CEOs similar incentives to increase systematic and idiosyncratic risk.

One concern with the results in Panel B of Table 2 is that the *J*-statistic is significant in the equations that model the level of idiosyncratic risk but insignificant in the equations that model the level of systematic and total risk. Since Hansen's (1982) test is a joint specification test of all the maintained assumptions of the estimation technique, a significant *J*-statistic indicates that at least one of the maintained assumptions is violated. In this case, a significant value of the *J*-statistic could result from incorrectly assuming that leverage is exogenous in its relationship with firm risk. We address this concern in the next section by taking into account the potentially endogenous nature of leverage when estimating the risk equations.

5.2. Firm risk profile with endogenous incentive contracts and leverage

Our next analysis further refines the research design in the previous section by treating firm leverage as endogenous in addition to CEO equity incentives. As discussed above, firm leverage and CEO equity incentives are likely to be jointly determined to achieve the firm's desired risk profile. Accordingly, treating leverage as exogenous potentially leads to biased estimates of the relationship between equity incentives and firms' risk profiles. We therefore model the amount of leverage as endogenously determined in this analysis.

The results of the first-stage contract design and leverage equations are presented in Panel A of Table 4 and are similar to those presented in Panel A of Table 2. In the leverage equation, we find that the predetermined variables generally exhibit an intuitive relationship with leverage. For example, we find that leverage is increasing in size and capital intensity (i.e., *Log(Sales)* and *PP&E*, respectively) and deceasing in growth opportunities (i.e., *Book-to-Market*). We also find that the signs of the coefficients on the instruments in the leverage equation are generally consistent with our predictions. In addition, the relatively high partial F-statistics (73.91 and 64.53, respectively) and partial R^2s (11.0% and 10.3%, respectively) in the equations, both without and with industry indicators, indicate that our instruments add significant explanatory power to the first-stage regressions and are therefore relevant.

The results of the second-stage risk-profile equations presented in Panel B of Table 4 continue to provide support for both of our hypotheses. In particular, we find that vega exhibits a positive and significant relationship with the level of total and systematic risk, but not the level of idiosyncratic risk. This finding is consistent with our first hypothesis and again suggests that although vega provides CEOs with incentives to increase risk, they might not necessarily induce CEOs to increase idiosyncratic risk when systematic risk is available as an alternative. In Table 5, we present the results of 3SLS estimation, which provides a formal test of our second hypothesis by allowing us to compare the estimated coefficients of vega across the systematic- and idiosyncratic-risk equations. The results indicate that the coefficient on vega is significantly higher in the systematic-risk equation than in the idiosyncratic-risk equation in both specifications. This finding is consistent with our second hypothesis and the results presented in Table 3.

Finally, consistent with the 2SLS results presented in Table 2, in Table 4 we find that delta is positive and significantly related to total risk and both its systematic and idiosyncratic components. Also consistent with the results in Table 3, the 3SLS results in Table 5 show that the coefficient on delta in the systematic-risk equation is not significantly different from its counterpart in the idiosyncratic-risk equation in either specification, which again suggests that delta does not provide CEOs with differential risk-taking incentives. Collectively, our findings in Tables 4 and 5 suggest that delta provides CEOs with similar incentives to take risk of either type to increase stock price.

Unlike the second-stage results presented in Panel B of Table 2, where we treat firm leverage as exogenous, we find that the magnitude of the *J*-statistic in this specification is considerably lower and no longer significant at conventional levels in five out of the six specifications in Panel B of Table 4. The diminished value and significance of the *J*-statistics in this specification, in which we also model leverage as endogenous, suggests that leverage is not exogenous, as was assumed in the earlier specifications. An insignificant *J*-statistic also provides evidence of the validity of our instruments, since it implies that our maintained assumption that the instruments are exogenous is unlikely to have been violated.

To allay any potential concerns related to the use of weak instruments, we also estimate just-identified versions of the risk-profile equations using only $Cash_t$, ROA_t, and $Return_t$ as instruments. Just-identified estimates are approximately median-unbiased and therefore unlikely to be subject to the traditional weak-instrument critiques (Angrist and Pischke, 2009a and 2009b). Untabulated results reveal that our inferences continue to hold in the just-identified systems, a finding that suggests that the results in Table 4 are not likely to be an artifact of weak instruments.

Another concern with our instrumental variables approach is the use of firms' cash balances as an instrument for equity incentives since cash balances might be jointly managed with firms' risk profiles. In particular, if firms that decide to pursue risky ventures also decide to keep a larger cash cushion on hand to avoid financial distress, and at the same time grant more equity incentives to reduce the agency problems associated with free cash flow, it would not be a valid instrument. We ensure that this scenario is not responsible for our results in two ways. First, since prior theoretical and empirical literature argues that it is financially constrained firms that maintain precautionary cash balances (e.g., Greenwald, Stiglitz, and Weiss 1984; Myers and Majluf, 1984; Almeida, Campello, and Weisbach, 2004; Denis and Sibilkov 2010), we remove variation in cash balances related to precautionary savings by regressing firms' cash balance on Hadlock and Pierce's (2010) size-age index of financial constraints. We then use the residual from this regression as an instrument and find that our reported results are robust to using residual cash balances as an alternative instrument. Second, we replace cash balances with two additional lags of operating and stock-price performance as alternative instruments and also find that our primary conclusions are unaltered.

In addition to our use of instrumental variables, the specific nature of our research question and our findings also help mitigate concerns about omitted variables that are correlated with both the use of ESOs and a firm's risk profile (e.g., the firm's growth opportunities or the CEO's risk tolerance). Such a correlated omitted variable would have to induce a positive correlation between vega and systematic risk but no correlation between vega and idiosyncratic risk to confound our estimates. Although such a variable could exist, this requirement precludes otherwise likely candidates for omitted correlated variables (e.g., growth opportunities and executive risk tolerance) and thus enhances the reliability of our results.

5.3. Acquisition analysis

Our earlier findings suggest the possibility that vega might not necessarily induce CEOs to pursue projects that are primarily characterized by idiosyncratic risk when projects with systematic risk are available as an alternative. We therefore conduct a complementary analysis that speaks directly to this possibility by examining a subsample of firms that engage in acquisitions. An acquisition setting is a useful one in which to examine differential risk-taking (and foregone risk-taking opportunities) because it allows us to identify not only the actual target that was acquired but also other potential targets that could have been acquired. We then compare the resulting risk profile of the acquirer and actual target with the risk profile that would have resulted if the CEO had instead acquired another similar target. This comparison allows us to directly assess the effect of CEOs' equity incentives on their choice of risk-taking decisions from the menu of alternative choices that would have been available.

We start by gathering information on the acquisition activity of our sample firms from the SDC Platinum database, and we combine multiple deals pertaining to the same acquirer and target that are less than one year apart into a single deal. We then match the actual target with a potential target that operates in the same (two-digit SIC) industry and has the closest market capitalization at the end of the month before the acquisition announcement as the firm that was acquired. We then create three indicator variables that compare the imputed risk profile of the combined acquirer and *actual* target with what the combined risk profile would have been if the acquirer had instead acquired the matched *potential* target.[18] Each indicator variable corresponds to each of the three risk-profile measures (i.e., total, idiosyncratic, and systematic risk) and takes a value of one if the risk-profile measure of the combined acquirer and actual target is greater than what it would have been if the acquirer had instead acquired the matched potential target, and zero otherwise. We then estimate three probit models in which we regress each of the three indicator variables on the CEOs' equity incentives (i.e., vega and delta) and control variables, which are measured at the end of the closest fiscal year before the announcement date of the acquisition for which data are available, but no earlier than two

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[18] Our methodology for imputing the risk profile of the entity obtained by combining acquirer with either the actual or a potential target is analogous to the one used in our primary analysis. In particular, we consider the acquirer and target as a portfolio of two assets and obtain the time series of portfolio returns by market-value-weighting the monthly returns of the acquirer and the target for up to 60 months before announcement of the acquisition. The market-value weights are estimated at the end of the month before the acquisition announcement and are held constant during the 60-month estimation window for imputed returns. If the target is a non-publicly traded subsidiary of a publicly traded parent firm, we use the stock returns of the parent firm to compute the imputed returns of the portfolio. We then estimate the risk profile of the combined entity by estimating the three-factor Fama-French model on this time series of monthly returns.

years before the announcement date. Our final sample consists of 3,559 acquisitions for which we have the required information to measure equity incentives and the control variables. To account for the endogenous nature of the relationship between equity incentives and leverage, and firms' risk profiles, we follow our earlier analysis and instrument for equity incentives and leverage. However, since this is a non-linear probit model, we estimate it using Newey's minimum chi-squared two-step estimator (Newey, 1987) rather than 2SLS.

One potential concern with our research design in this analysis is that the procedure used to identify a potential target does not explicitly take into account acquisition synergies, which are inherently unobservable for potential targets. However, this is unlikely to be a source of significant concern for two reasons. First, there is no obvious reason why our matching procedure would identify potential targets such that the differential acquisition synergies associated with the actual target and the potential target are systematically correlated with the equity incentives of the acquirers' CEOs. Second, since we estimate the probit models using instrumental variables, this should mitigate concerns about biases induced by potential omitted correlated variables of this nature.

The results of this analysis are presented in Table 6. In the first two columns we find that vega significantly increases the probability that CEOs make acquisitions that increase their firms' total risk relative to other potential acquisitions that they could have made. Most importantly, in the last four columns, we find that CEOs with higher vega are more likely to acquire firms that increase their firms' systematic risk, but not idiosyncratic risk, relative to other firms they could have acquired. These findings provide further evidence that vega may not induce managers to increase their firms' idiosyncratic risk when opportunities to increase their firms' systematic risk are instead available.

We also find that delta significantly increases the probability that CEOs make acquisitions that increase their firms' idiosyncratic risk relative to alternative acquisitions they could have made. However, we do not find evidence that delta affects the probability that CEOs make acquisitions that affect either the level of systematic or total risk relative to alternative potential acquisitions. These results corroborate our earlier findings (in Tables 2 and 4) and indicate that delta provides managers with incentives to increase idiosyncratic risk. These results also speak directly to the risk-value tradeoff, since they suggest that delta induces managers to choose value-increasing acquisitions even if they increase their firms' undiversifiable idiosyncratic risk.

Collectively, our findings in an acquisition setting complement our earlier results and have important implications for compensation policy and firm value. Prior literature has argued that ESOs can be used to mitigate managers' aversion to investing in risky but positive-NPV projects. Our results qualify this argument and imply that to the extent the positive-NPV projects are primarily characterized by idiosyncratic risk, ESOs might not necessarily induce managers to pursue these projects when projects with systematic risk are available as an alternative.

6. Conclusion

This study examines the relationship between the risk-taking incentives provided by executive stock options and the systematic and idiosyncratic components of firm risk. Theory suggests that vega gives risk-averse managers more of an incentive to increase total risk by increasing systematic rather than idiosyncratic risk, since, for a given level of vega, an increase in systematic risk always results in a greater increase in a CEO’s subjective value of his or her stock-option portfolio than does an equivalent increase in idiosyncratic risk. This differential risk-taking incentive manifests because a CEO who can trade the market portfolio can hedge any unwanted increase in the firm’s systematic risk. Consistent with this prediction, we provide evidence of a strong positive relationship between vega and the level of both total and systematic risk. However, we do not find vega and idiosyncratic risk to be significantly related.

ESOs also give CEOs incentives to alter their firms’ risk profile through their sensitivity to stock price, or delta. We find that delta is positively related to the level of both systematic and idiosyncratic, and therefore total, risk. The positive relationship between delta and idiosyncratic risk is particularly noteworthy and suggests that investing in positive-NPV projects may require managers to increase idiosyncratic risk even though it cannot be hedged.

Our results challenge the popular belief that ESOs can be used to overcome risk-averse CEOs’ aversion to investing in risky but positive-NPV projects. Our findings suggest that ESOs may not necessarily induce CEOs to undertake positive-NPV projects if these projects are primarily characterized by idiosyncratic risk and opportunities to increase systematic risk are available. Our findings also raise the possibility that ESOs may induce managers to increase their firms’ systematic risk, which they can hedge, even if it does not increase firm value. This can adversely affect shareholders in two ways. First, there could be costs associated with managerial time and effort spent seeking systematic risk that does not necessarily increase firm value. Second, it could lead to excessive systematic risk in equity markets, which may, in turn, lead to reduced risk-sharing among investors and lower firm values.

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Appendix

This appendix describes the model (based closely on Tian, 2004) and the numerical procedure used to calculate the certainty equivalent of a CEO's portfolio for generating Fig. 1. We begin by assuming that the CEO is risk-averse and his or her preferences can be represented with the power utility function, $u(w) = \frac{w^{1-a}}{1-a}$, where *w* is the CEO's terminal wealth and *a* is the CEO's coefficient of relative risk aversion. The CEO can invest (both long and short) his or her cash wealth in both the risk-free asset and the market portfolio. The CEO's problem is to maximize his or her expected utility by optimally allocating his or her cash wealth between the risk-free asset and the market portfolio given the risk profile of the firm.

Letting w_0 denote the CEO's initial cash wealth, *n* denote the number of stock options, *q* denote the number of shares, and *m* denote the fraction of CEO's cash wealth that he or she invests in the market portfolio, we can write the CEO's end-of-period wealth as

$$\tilde{w}(m,n,q) = w_0 m(1+\tilde{r}_m) + w_0(1-m)(1+r_f) + n.\max(\tilde{s}-k,0) + q.\tilde{s},$$

where $\tilde{r}_m$ is the return on the market portfolio, r_f is the return on the risk-free asset, $\tilde{s}$ is the firm's end-of-period stock price, and *k* is the exercise price of the stock options. The CEO chooses *m* to maximize the expected utility of his or her terminal wealth. The CEO's maximum expected utility, $EU^*(n,q)$, from optimally allocating his or her cash wealth between the risk-free asset and the market portfolio can be expressed as

$$EU^*(n,q) = \underset{m}{Max} \quad E\{u(\tilde{w}(m,n,q))\}.$$

The certainty equivalent of the CEO's portfolio can be written as

$$CE(n,q) = [(1-a)EU^{*}(n,q)]^{\frac{1}{1-a}}.$$

This model does not have a closed-form solution because of the nonlinear payoff of the stock options. Therefore, to solve for the CEO's certainty equivalent of his or her portfolio, which we use to generate Fig. 1, we simulate the price process for the market portfolio and firm's stock and solve the CEO's optimization problem numerically. To perform these simulations, we assume that the firm's end-of-period stock price and the market portfolio follow a joint geometric Brownian motion described by

$$\tilde{s} = s_0 \exp(\mu_s - \frac{1}{2}\sigma_s^2 + \sigma_s \tilde{\varepsilon}_s)$$

$$\tilde{M} = M_0 \exp(\mu_m - \frac{1}{2}\sigma_m^2 + \sigma_m \tilde{\varepsilon}_m),$$

where s_0 and M_0 are the firm's initial stock price and the initial value of the market portfolio, respectively; μ_s and σ_s are the expected return and the volatility of the firm's stock; μ_m and σ_m are the expected return and the volatility of the market portfolio; and $\tilde{\varepsilon}_s$ and $\tilde{\varepsilon}_m$ are joint normal shocks with correlation ρ. We further assume that the firm's expected return is given by the Capital Asset Pricing Model:

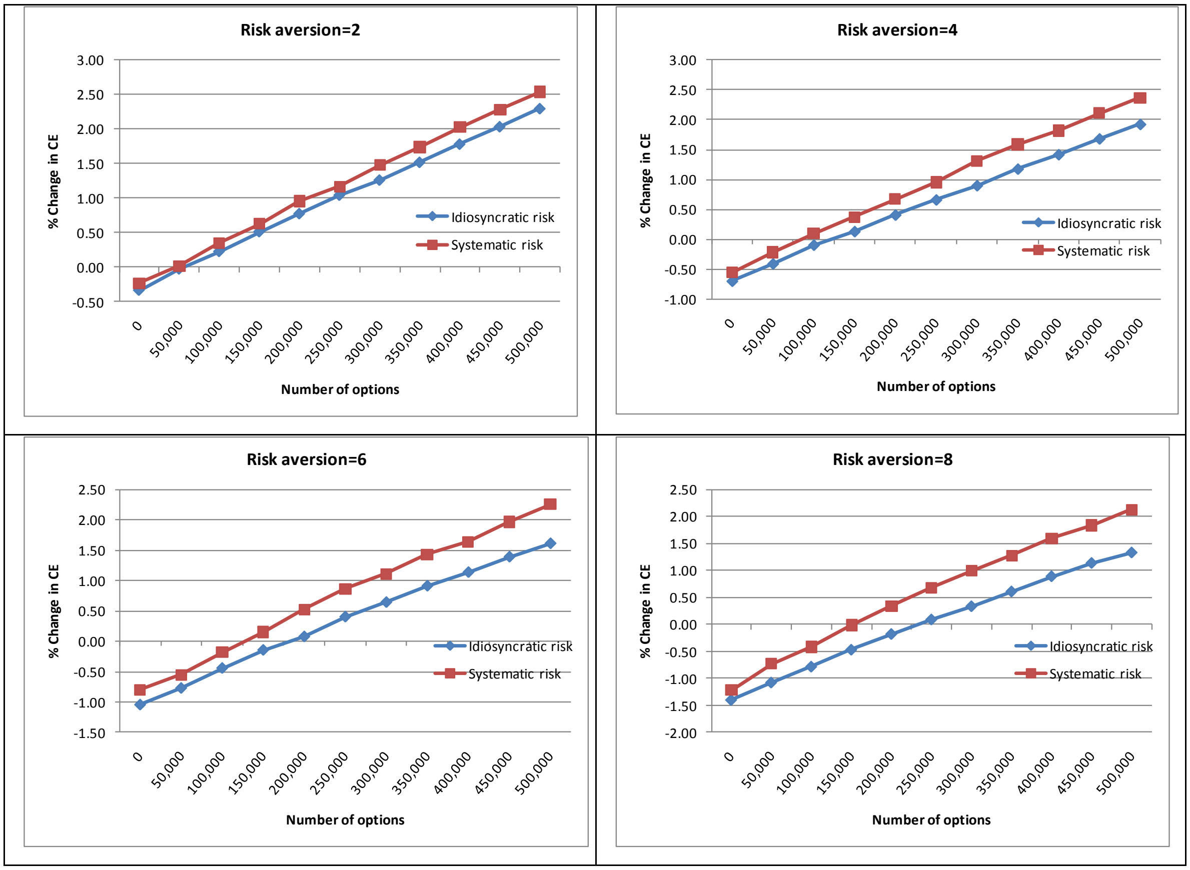
$$\mu_s = r_f + \beta(\mu_m - r_f)$$

$$\beta = \frac{\rho\sigma_s}{\sigma_m}.$$

The specific parameterization of the above model used to generate Fig. 1 is described in its caption.

Figure 1

Change in Subjective Value of Equity Portfolio as a Function of Vega for Changes in Systematic and Idiosyncratic Risk



This figure displays a CEO's incentives to alter his or her firm's systematic and idiosyncratic risk while holding the other constant for different levels of vega and CEO risk aversion. Risk-taking incentives are measured as the percentage change in the subjective value, or certainty equivalent, of the CEO's portfolio for a 0.05 change in either the systematic or idiosyncratic volatility of firm's stock returns while holding the other constant. The CEO is assumed to have power utility with a coefficient of relative risk aversion of either two, four, six, or eight (moving clockwise starting from the top left panel). This analysis alters the vega (i.e., the sensitivity of the options' Black-Scholes value to changes in return volatility) of the CEO's firm-specific equity portfolio while holding both the market value of the CEO's total wealth constant at $10 million and the delta (i.e., the sum of the sensitivity of the options' Black-Scholes value and shares' market value to changes in stock price) of the CEO's firm-specific equity portfolio constant at $300,000. Thus, for a given number of options, the number of shares held by the CEO is calculated to keep the CEO's equity portfolio delta equal to $300,000, and the CEO's outside wealth is then determined such that his or her total wealth is equal to $10 million. The CEO's options are assumed to be at-the-money, and the CEO optimally allocates his or her outside wealth (both long and short) between the risk-free asset and the market portfolio to maximize his or her expected utility. The certainty equivalent of the CEO's portfolio is computed by simulating the model described in the Appendix for a daily holding period. The annualized parameters for the stock-price process and the market-value process are as follows: stock price = $30; idiosyncratic-return volatility = 30%; systematic-return volatility = 30%; market-return volatility = 20%; market-risk premium = 7%; risk-free rate = 2%.

Table 1

Descriptive Statistics

	Mean	Standard Deviation	10th Percentile	50th Percentile	90th Percentile
Risk Profile Measures					
Total Risk	0.07	0.03	0.04	0.06	0.12
Systematic Risk	0.06	0.03	0.03	0.05	0.10
Idiosyncratic Risk	0.04	0.02	0.02	0.04	0.06
CEO Characteristics					
Vega ($000s)	100	174	3	38	252
Delta ($000s)	718	1,799	31	207	1,505
Tenure (years)	8	8	1	6	18
Cash Compensation ($000s)	1,168	1,011	368	873	2,300
Firm Characteristics					
Sales ($ millions)	4,427	13,041	173	1,091	9,287
Book-to-Market	0.61	0.26	0.27	0.60	0.96
Leverage	0.22	0.17	0.00	0.20	0.44
Growth	0.11	0.22	-0.10	0.09	0.34
PP&E	0.30	0.22	0.07	0.24	0.64
Cash	0.14	0.17	0.01	0.07	0.40
TaxLoss	0.36	0.48	0.00	0.00	1.00
ROA	0.05	0.11	-0.05	0.06	0.16
Return	0.19	0.64	-0.36	0.10	0.74

This table presents descriptive statistics for our sample of 13,223 firm years from 1992 to 2007 in which the primary variables are grouped according to *Risk Profile Measures*, *CEO Characteristics*, and *Firm Characteristics*. Firm risk is measured using the imputed monthly returns based on the industry segments in which the firm operates and is estimated using the three Fama and French factors as described in Section 4. *Systematic Risk* is the square root of the variance of firm returns explained by the Fama-French three-factor model. *Idiosyncratic Risk* is the square root of the residual variance from the Fama-French three-factor model. *Total Risk* is the standard deviation of firm returns. *Vega* is the change in the risk-neutral value of the CEO's portfolio of stock options for a 0.01 change in the standard deviation of the return of the underlying stock. *Delta* is the change in the risk-neutral value of the CEO's equity portfolio of stock and options for a 1% change in the price of the underlying stock. *Tenure* is the number of years in which the current CEO has held his or her office. *CashCompensation* is the total value of cash the CEO received during the year. *Sales* is the firm's annual revenue. *Book-to-Market* is the ratio of book value to market value of total assets. *Leverage* is the book value of total long-term debt scaled by total assets. *Growth* is the growth in annual sales over the prior year. *PP&E* is the net plant, property, and equipment scaled by total assets. *Cash* is the firm's total cash balance scaled by total assets. *TaxLoss* is an indicator variable equal to one if a firm has tax-loss carry-forwards in any of the past three years and zero otherwise. *ROA* is net income scaled by beginning-of-year book value of assets. *Return* is the cumulative stock return over the fiscal year. *Vega*, *Delta*, *Leverage*, *Book-to-Market*, *CashCompensation*, and *PP&E* are winsorized at the first and 99th percentiles.

Table 2
Two-Stage Least Squares Results

Panel A: First-Stage Contract Design Equations

	Vega	*Delta*	*Vega*	*Delta*
Log(Sales)	0.336***	0.382***	0.379***	0.406***
	(14.96)	(22.58)	(16.70)	(23.09)
Leverage	0.522***	0.157	0.464***	0.113
	(3.439)	(1.187)	(3.150)	(0.893)
Book-to-Market	-1.173***	-2.221***	-1.001***	-2.145***
	(-10.26)	(-23.45)	(-9.063)	(-23.08)
Growth	0.0151	0.495***	-0.0115	0.449***
	(0.213)	(7.530)	(-0.167)	(7.199)
CashCompensation	0.402***	0.188***	0.371***	0.152***
	(12.01)	(8.383)	(11.62)	(7.011)
Tenure	-0.018***	0.066***	-0.016***	0.065***
	(-4.311)	(20.32)	(-4.034)	(20.82)
PP&E	-0.103	0.0272	-0.388**	-0.0649
	(-0.784)	(0.244)	(-2.093)	(-0.432)
Cash	0.940***	0.655***	0.740***	0.658***
	(4.799)	(4.048)	(3.752)	(4.053)
TaxLoss	0.0963**	0.01000	0.0410	-0.00625
	(2.082)	(0.257)	(0.913)	(-0.168)
ROA	-0.640***	0.275*	-0.545***	0.278*
	(-3.440)	(1.646)	(-2.885)	(1.719)
$Return_t$	-0.194***	0.114***	-0.174***	0.133***
	(-7.054)	(6.139)	(-6.452)	(7.315)
$Return_{t-1}$	-0.073***	0.078***	-0.067***	0.082***
	(-3.418)	(4.494)	(-3.159)	(4.897)
Industry Indicators	No	No	Yes	Yes
R^2	34.1%	52.7%	38.0%	56.1%
Partial R^2	2.1%	1.3%	1.4%	1.5%
Partial *F*-Statistics	24.78	13.21	16.78	17.42
Observations	13,233	13,233	12,987	12,987

This table presents the results of the first-stage contract design equations when equity-portfolio sensitivity to changes in stock return volatility (*Vega*) and equity-portfolio sensitivity to changes in stock price (*Delta*) are treated as endogenous and are regressed on predetermined variables and the instruments. The predetermined variables are $Log(Sales_t)$, $Leverage_t$, $Book\text{-}to\text{-}Market_t$, $Growth_t$, $CashCompensation_t$, $Tenure_t$, and $PP\&E_t$. The instruments are $Cash_t$, $TaxLoss_t$, ROA_t, $Return_t$, and $Return_{t-1}$. All variables are as defined in the caption of Table 1. Industry Indicators are excluded in the first two columns and included in the last two columns. When Industry indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Partial R^2 is the partial R^2 from including the instruments in the equations. Partial *F*-statistics are the partial *F*-statistics obtained from including the instruments in the equations, and the associated *p*-value is reported below in parentheses. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors clustered at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 2 (continued)
Two-Stage Least Squares Results

Panel B: Second-Stage Risk-Profile Equations

	Total Risk		*Systematic Risk*		*Idiosyncratic Risk*	
Log(Vega)	0.115***	0.079***	0.149***	0.125***	0.006	-0.002
	(2.860)	(3.809)	(3.228)	(4.431)	(0.181)	(-0.0996)
Log(Delta)	0.283***	0.069***	0.260***	0.060*	0.289***	0.077***
	(4.748)	(2.739)	(4.044)	(1.750)	(4.867)	(3.495)
Log(Sales)	-0.160***	-0.058***	-0.163***	-0.073***	-0.122***	-0.029**
	(-5.261)	(-3.874)	(-4.825)	(-3.555)	(-4.446)	(-2.386)
Leverage	-0.285***	-0.077***	-0.331***	-0.126***	-0.141**	-0.000
	(-4.578)	(-2.989)	(-4.855)	(-3.632)	(-2.435)	(-0.00490)
Book-to-Market	0.857***	0.243***	0.825***	0.250**	0.801***	0.210***
	(4.923)	(3.329)	(4.356)	(2.506)	(4.702)	(3.345)
Growth	-0.103**	-0.022	-0.124***	-0.030	-0.068*	-0.007
	(-2.513)	(-1.301)	(-2.783)	(-1.296)	(-1.760)	(-0.478)
CashCompensation	-0.109***	-0.046***	-0.120***	-0.063***	-0.060***	-0.010
	(-4.260)	(-4.030)	(-4.174)	(-4.003)	(-2.626)	(-1.036)
Tenure	-0.017***	-0.003*	-0.015***	-0.001	-0.019***	-0.005***
	(-4.497)	(-1.772)	(-3.615)	(-0.644)	(-5.061)	(-3.548)
PP&E	0.007	0.057*	-0.402***	-0.050	0.575***	0.197***
	(0.144)	(1.825)	(-8.137)	(-1.197)	(11.23)	(6.830)
Industry Indicators	No	Yes	No	Yes	No	Yes
Hansen *J*-Statistics (*p*-value)	0.65 (0.885)	3.92 (0.271)	1.36 (0.714)	4.33 (0.228)	7.12 (0.068)	10.92 (0.012)
Observations	13,233	12,987	13,233	12,987	13,233	12,987

This table presents the second-stage regression results from the estimation of risk equations (1) - (3) using two-stage least squares for the case when equity-portfolio sensitivity to changes in stock return volatility (*Vega*) and equity-portfolio sensitivity to changes in stock price (*Delta*) are treated as endogenous. The predetermined variables are *Log(Sales*$_t$*)*, *Leverage*$_t$, *Book-to-Market*$_t$, *Growth*$_t$, *CashCompensation*$_t$, *Tenure*$_t$, and *PP&E*$_t$. The instruments are *Cash*$_t$, *TaxLoss*$_t$, *ROA*$_t$, *Return*$_t$, and *Return*$_{t-1}$. All variables are as defined in the caption of Table 1. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors clustered at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 3

Three-Stage Least Squares Estimation

	Systematic Risk	*Idiosyncratic Risk*	*Systematic Risk*	*Idiosyncratic Risk*
Log(Vega)	0.149***	0.006	0.125***	-0.002
	(3.074)	(0.173)	(5.105)	(-0.0946)
Log(Delta)	0.260***	0.289***	0.060**	0.077***
	(3.947)	(5.041)	(2.015)	(4.084)
Log(Sales)	-0.163***	-0.122***	-0.073***	-0.029**
	(-4.461)	(-4.569)	(-4.049)	(-2.467)
Leverage	-0.331***	-0.141**	-0.126***	-0.000
	(-4.886)	(-2.275)	(-3.365)	(-0.00586)
Book-to-Market	0.825***	0.801***	0.250***	0.210***
	(4.163)	(4.930)	(2.877)	(3.808)
Growth	-0.124**	-0.068	-0.030	-0.007
	(-2.502)	(-1.643)	(-1.528)	(-0.495)
CashCompensation	-0.120***	-0.060***	-0.063***	-0.010
	(-3.965)	(-2.811)	(-4.784)	(-1.093)
Tenure	-0.015***	-0.019***	-0.001	-0.005***
	(-3.517)	(-5.080)	(-0.738)	(-4.243)
PP&E	-0.402***	0.575***	-0.050	0.197***
	(-8.007)	(11.12)	(-1.111)	(6.809)
Industry Indicators	No	No	Yes	Yes
Observations	13,233	12,987	13,233	12,987
Comparison of coefficients on Log(Vega): Test for $\gamma_1>\delta_1$ (Null Hypothesis: $\gamma_1=\delta_1$)				
$\gamma_1 - \delta_1$	0.143		0.127	
z-statistics	3.409		4.362	
p-value	0.001		0.000	
Comparison of coefficients on Log(Delta): Test of $\gamma_2>\delta_2$ (Null Hypothesis: $\gamma_2=\delta_2$)				
$\gamma_2 - \delta_2$	-0.029		-0.017	
z-statistics	-0.487		-0.538	
p-value	0.626		0.591	

This table presents the results from the simultaneous estimation of Eq. (2) and Eq. (3) using three-stage least squares for the case when equity-portfolio sensitivity to changes in stock return volatility (*Vega*) and equity-portfolio sensitivity to changes in stock price (*Delta*) are treated as endogenous. The predetermined variables are $Log(Sales_t)$, $Leverage_t$, $Book\text{-}to\text{-}Market_t$, $Growth_t$, $CashCompensation_t$, $Tenure_t$, and $PP\&E_t$. The instruments are $Cash_t$, $TaxLoss_t$, ROA_t, $Return_t$, and $Return_{t-1}$. All variables are as defined in the caption of Table 1. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors obtained using clustered bootstrapping at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 4
Two-Stage Least Squares With Endogenous Leverage

Panel A: First-Stage Contract Design Equations

	Vega	*Delta*	*Leverage*	*Vega*	*Delta*	*Leverage*
Log(Sales)	0.341***	0.383***	0.008***	0.383***	0.407***	0.009***
	(15.25)	(22.77)	(2.864)	(16.97)	(23.23)	(3.159)
Book-to-Market	-1.137***	-2.210***	0.069***	-0.974***	-2.139***	0.057***
	(-9.936)	(-23.55)	(4.402)	(-8.846)	(-23.18)	(3.673)
Growth	0.037	0.501***	0.043***	0.007	0.453***	0.040***
	(0.524)	(7.560)	(3.996)	(0.103)	(7.222)	(3.974)
CashCompensation	0.409***	0.190***	0.013***	0.374***	0.153***	0.007**
	(12.18)	(8.457)	(4.136)	(11.65)	(7.019)	(2.339)
Tenure	-0.018***	0.066***	-0.001	-0.016***	0.065***	-0.000
	(-4.354)	(20.29)	(-1.453)	(-4.070)	(20.81)	(-1.401)
PP&E	-0.060	0.040	0.084***	-0.366**	-0.060	0.047**
	(-0.457)	(0.364)	(5.372)	(-1.967)	(-0.396)	(2.192)
Cash	0.791***	0.610***	-0.285***	0.616***	0.628***	-0.268***
	(4.094)	(3.825)	(-11.62)	(3.155)	(3.885)	(-10.84)
TaxLoss	0.110**	0.014	0.026***	0.053	-0.003	0.027***
	(2.352)	(0.361)	(4.383)	(1.179)	(-0.0870)	(4.680)
ROA	-0.828***	0.218	-0.361***	-0.704***	0.239	-0.344***
	(-4.419)	(1.327)	(-9.219)	(-3.761)	(1.492)	(-9.021)
$Return_t$	-0.191***	0.115***	0.006**	-0.173***	0.134***	0.004
	(-6.931)	(6.204)	(2.303)	(-6.380)	(7.350)	(1.635)
$Return_{t-1}$	-0.074***	0.078***	-0.001	-0.068***	0.082***	-0.002
	(-3.469)	(4.505)	(-0.506)	(-3.218)	(4.898)	(-0.807)
Industry Indicators	No	No	No	Yes	Yes	Yes
R^2	33.9%	52.7%	24.6%	37.9%	56.1%	31.5%
Partial R^2	2.1%	1.2%	11.0%	1.4%	1.4%	10.3%
Partial *F*-Statistics	24.65	12.55	73.91	16.93	16.77	64.53
Observations	13,233	13,233	13,233	12,987	12,987	12,987

This table presents the results of the first-stage contract design equations when equity-portfolio sensitivity to changes in stock return volatility (*Vega*), equity-portfolio sensitivity to changes in stock price (*Delta*), and *Leverage* are treated as endogenous and are regressed on predetermined variables and the instruments. The predetermined variables are $Log(Sales_t)$, $Book\text{-}to\text{-}Market_t$, $Growth_t$, $CashCompensation_t$, $Tenure_t$, and $PP\&E_t$. The instruments are $Cash_t$, $TaxLoss_t$, ROA_t, $Return_t$, and $Return_{t-1}$. All variables are as defined in the caption of Table 1. Industry indicators are excluded in the first three columns and included in the last three columns. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Partial R^2 is the partial R^2 from including the instruments in the equations. Partial *F*-statistics are the partial *F*-statistics obtained from including the instruments in the equations, and the associated *p*-value is reported below in parentheses. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors clustered at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 4 (continued)
Two-Stage Least Squares With Endogenous Leverage

Panel B: Second-Stage Risk-Profile Equations

	Total Risk		*Systematic Risk*		*Idiosyncratic Risk*	
Log(Vega)	0.116***	0.083***	0.155***	0.135***	-0.007	-0.009
	(2.738)	(3.547)	(3.010)	(4.021)	(-0.252)	(-0.561)
Log(Delta)	0.289***	0.085***	0.309***	0.100**	0.175***	0.047**
	(3.807)	(2.582)	(3.430)	(2.087)	(3.020)	(1.983)
Leverage	-0.266	-0.018	-0.169	0.018	-0.522***	-0.111*
	(-1.364)	(-0.196)	(-0.747)	(0.141)	(-3.540)	(-1.826)
Log(Sales)	-0.162***	-0.066***	-0.184***	-0.093***	-0.073***	-0.013
	(-4.183)	(-3.359)	(-3.953)	(-3.250)	(-2.644)	(-1.041)
Book-to-Market	0.868***	0.276***	0.921***	0.330***	0.575***	0.149**
	(4.279)	(3.116)	(3.827)	(2.582)	(3.709)	(2.373)
Growth	-0.107**	-0.032	-0.156***	-0.054*	0.008	0.012
	(-2.158)	(-1.525)	(-2.676)	(-1.804)	(0.225)	(0.769)
CashCompensation	-0.111***	-0.050***	-0.134***	-0.073***	-0.028	-0.002
	(-3.594)	(-3.667)	(-3.591)	(-3.672)	(-1.233)	(-0.159)
Tenure	-0.017***	-0.004*	-0.017***	-0.004	-0.012***	-0.003**
	(-3.636)	(-1.860)	(-3.156)	(-1.283)	(-3.329)	(-2.114)
PP&E	0.005	0.057*	-0.418***	-0.051	0.612***	0.198***
	(0.0989)	(1.712)	(-7.264)	(-1.118)	(13.44)	(7.316)
Industry Indicators	No	Yes	No	Yes	No	Yes
Hansen *J*-Statistics (*p*-value)	0.619 (0.734)	2.855 (0.240)	0.575 (0.750)	1.794 (0.408)	2.293 (0.318)	8.772 (0.013)
Observations	13,233	12,987	13,233	12,987	13,233	12,987

This table presents the second-stage regression results from the estimation of risk equations (1) - (3) using two-stage least squares for the case when equity-portfolio sensitivity to changes in stock return volatility (*Vega*), equity-portfolio sensitivity to changes in stock price (*Delta*), and *Leverage* are treated as endogenous. The predetermined variables are $Log(Sales_t)$, $Book\text{-}to\text{-}Market_t$, $Growth_t$, $CashCompensation_t$, $Tenure_t$, and $PP\&E_t$. The instruments are $Cash_t$, $TaxLoss_t$, ROA_t, $Return_t$, and $Return_{t-1}$. All variables are as defined in the caption of Table 1. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Year indicators were included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors clustered at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 5

Three-Stage Least Squares Estimation

	Systematic Risk	*Idiosyncratic Risk*	*Systematic Risk*	*Idiosyncratic Risk*
Log(Vega)	0.155***	-0.007	0.135***	-0.009
	(2.823)	(-0.231)	(3.316)	(-0.525)
Log(Delta)	0.309***	0.175***	0.100	0.047*
	(3.004)	(2.863)	(1.527)	(1.928)
Leverage	-0.169	-0.522***	0.018	-0.111
	(-0.734)	(-3.223)	(0.113)	(-1.588)
Log(Sales)	-0.184***	-0.073**	-0.093**	-0.013
	(-3.601)	(-2.447)	(-2.389)	(-0.969)
Book-to-Market	0.921***	0.575***	0.330**	0.149**
	(3.333)	(3.468)	(1.966)	(2.269)
Growth	-0.156**	0.008	-0.054	0.012
	(-2.545)	(0.237)	(-1.318)	(0.788)
CashCompensation	-0.134***	-0.028	-0.073***	-0.002
	(-3.236)	(-1.091)	(-3.005)	(-0.159)
Tenure	-0.017***	-0.012***	-0.004	-0.003**
	(-2.860)	(-3.310)	(-1.003)	(-2.018)
PP&E	-0.418***	0.612***	-0.051	0.198***
	(-7.651)	(14.27)	(-0.991)	(6.613)
Industry Indicators	No	No	Yes	Yes
Observations	13,233	12,987	13,233	12,987
Comparison of coefficients on Log(Vega): Test for $\gamma_1>\delta_1$ (Null Hypothesis: $\gamma_1=\delta_1$)				
$\gamma_1 - \delta_1$	0.163		0.144	
z-statistics	2.986		3.523	
p-value	0.003		0.000	
Comparison of coefficients on Log(Delta): Test for $\gamma_2>\delta_2$ (Null Hypothesis: $\gamma_2=\delta_2$)				
$\gamma_2 - \delta_2$	0.134		0.053	
z-statistics	1.502		1.217	
p-value	0.133		0.224	

This table presents the results from the simultaneous estimation of Eq. (2) and Eq. (3) using three-stage least squares for the case when equity-portfolio sensitivity to changes in stock return volatility (*Vega*), equity-portfolio sensitivity to changes in stock price (*Delta*), and *Leverage* are treated as endogenous. The predetermined variables are $Log(Sales_t)$, $Book\text{-}to\text{-}Market_t$, $Growth_t$, $CashCompensation_t$, $Tenure_t$, and $PP\&E_t$. The instruments are $Cash_t$, $TaxLoss_t$, ROA_t, $Return_t$, and $Return_{t-1}$. All variables are as defined in the caption of Table 1. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *t*-statistics are reported below coefficient estimates in parentheses and are calculated based on robust standard errors obtained using clustered bootstrapping at the firm level. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Table 6

The Effect of Equity Incentives on Changes in Firms' Risk Profiles From Acquisitions

	Probability of Increase in Total Risk		*Probability of Increase in Systematic Risk*		*Probability of Increase in Idiosyncratic Risk*	
Log(Vega)	0.227**	0.257**	0.189**	0.224**	-0.0456	-0.0783
	(2.464)	(2.254)	(2.061)	(1.987)	(-0.406)	(-0.557)
Log(Delta)	-0.0200	-0.0151	0.0736	0.0585	0.211*	0.406***
	(-0.215)	(-0.143)	(0.801)	(0.563)	(1.658)	(2.722)
Log(Sales)	-1.997***	-2.326***	-1.778***	-2.130***	1.459*	1.348
	(-3.216)	(-2.948)	(-2.882)	(-2.728)	(1.949)	(1.366)
Leverage	-0.000520	0.0147	-0.0446	-0.0405	-0.115	-0.179*
	(-0.00842)	(0.197)	(-0.730)	(-0.550)	(-1.454)	(-1.881)
Book-to-Market	0.663***	0.682**	0.506**	0.513*	-0.0159	0.424
	(2.664)	(2.368)	(2.048)	(1.805)	(-0.0535)	(1.147)
Growth	0.171	0.173	-0.00230	0.0214	-0.0721	-0.174
	(1.503)	(1.587)	(-0.0207)	(0.200)	(-0.512)	(-1.266)
CashCompensation	-0.041**	-0.052***	-0.044***	-0.054***	-0.060***	-0.044*
	(-2.477)	(-2.686)	(-2.700)	(-2.857)	(-3.091)	(-1.874)
Tenure	0.097	0.107	-0.033	-0.029	-0.219*	-0.373***
	(1.145)	(1.234)	(-0.400)	(-0.347)	(-1.897)	(-2.851)
PP&E	0.275**	-0.262	0.358***	-0.113	0.588***	0.348
	(1.986)	(-1.287)	(2.594)	(-0.567)	(3.475)	(1.312)
Industry Indicators	No	Yes	No	Yes	No	Yes
Observations	3,559	3,559	3,559	3,559	3,559	3,559

This table presents the probit regression results from estimating models with indicator variables that compare the risk profile achieved from actual acquisitions and potential acquisitions using Newey's minimum chi-squared two-step estimator (Newey, 1987) for the case in which equity-portfolio sensitivity to changes in stock return volatility (*Vega*), equity-portfolio sensitivity to changes in stock price (*Delta*), and *Leverage* are treated as endogenous. The dependent variables in each specification are an indicator that takes a value of one if the resulting level of total, systematic, or idiosyncratic risk respectively, of the combined acquirer and *actual* target is greater than the level of the risk measure obtained for the combined acquirer and the matched *potential* target, which is identified as the firm with the closest market capitalization in the actual target's two-digit SIC industry. The predetermined variables are *Log(Sales*$_t$*)*, *Book-to-Market*$_t$, *Growth*$_t$, *CashCompensation*$_t$, *Tenure*$_t$, and *PP&E*$_t$. The instruments are *Cash*$_t$, *TaxLoss*$_t$, *ROA*$_t$, *Return*$_t$, and *Return*$_{t-1}$. All variables are as defined in the caption of Table 1. The coefficients on *Tenure*$_t$ are multiplied by ten to facilitate their exposition. When Industry Indicators are included, each indicator takes a value of one for each firm that has segment operations in that two-digit SIC industry and zero otherwise. Year indicators are included in all the equations. Coefficient estimates for the industry and year indicators are not reported. *z*-statistics are reported below coefficient estimates in parentheses. Statistical significance (two-sided) at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.