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Work hard, not smart: Stock options in executive compensation

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Abstract

This paper examines the optimal equity compensation for executives. When executives choose a level of effort to devote to gathering information and a criterion for acting on the information gathered, the optimal exercise price involves a trade-off; a higher exercise price moves the executive's decision criterion away from first-best but provides leverage that moves the executive's effort toward first-best. This trade-off depends on a variety of factors, including the potential influence of decisions on firm value. We document empirical regularities consistent with the theory such as that options are relatively less prevalent in the equity compensation of more-senior executives.

JEL classification: J33; J41; G3

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1. Introduction

A central thesis of the extensive principal-agent literature is that compensation offered by risk-neutral principals to risk-averse agents results in second-best outcomes. The standard "textbook" view is that stock options, by introducing convexity in rewards, counter the otherwise-conservative decision-making of risk-averse managers and thus encourage the adoption of high valued projects even if they are riskier (e.g., Milgrom and Roberts, 1992).[1] However, such a view fails to account

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[1] Guay (1999), among others, formally investigates the role for stock options in controlling risk-related incentive problems that arise when agents are risk-averse. Other rationales for the broad-based use of options include the retention

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for other findings, such as those of Lambert et al. (1991), who demonstrate that when the probability of finishing in-the-money is sufficiently high, stock options can actually *increase* a manager's aversion to risk. In other words, "the effects of option compensation on the manager's appetite for risk are more complex than simple intuition about option pricing might suggest" (Carpenter, 2000, p. 2327). Ross (2004, p. 207) also brings the simple textbook view into question, noting that "the common folklore that giving options to agents will make them more willing to take risks is false" insofar as no incentive schedule will make all expected utility maximizers more or less risk-averse.

This paper explores the optimal use of stock options in the compensation packages of top executives without relying solely on agent risk aversion.[2] Formally, we model an executive's decision-making as having two distinct elements. First, the executive chooses an evaluation effort that affects the quality of information surrounding a project-selection decision. In this context, options provide a positive leveraging effect that enhances incentives to collect relevant information on the value of an uncertain proposal.[3] Second, the executive applies a decision criterion to the information gathered that determines whether a proposed alternative is to be accepted or rejected.[4]

In the limiting case of a risk-neutral decision-maker, the choice of the optimal exercise price (and corresponding number of options that maintains a given expected compensation level) can be framed in terms of the following simple trade-off. A higher exercise price provides leverage gains as the resulting higher number of options awarded increases the incentive for the executive to collect information on proposals. However, a higher exercise price increases the bias in the executive's decision criterion and thus imposes costs to shareholders with respect to how the executive acts on the information gathered. In short, in contrast to the common adage that managers should "work smart, not hard," we find that an equal-expected-value option grant that has a higher exercise price encourages a "work hard, not smart" approach.[5] Of course, if the executive is risk-averse, the leverage gains to an increase in the exercise price remain while the bias introduced into the decision-making criterion from an increase in the exercise price will initially be of value to the shareholder. Ultimately, however, the trade-

and sorting of workers (e.g., Oyer and Schaefer, 2005) or false perceptions that stock options are inexpensive because of accounting and cash-flow considerations (i.e., Hall and Murphy, 2003).

[2] Given that diversified shareholders value risk-neutral managers, it is reasonable to presume that the selection process can result in top executives exhibiting low risk aversion.

[3] Using numerical examples, Lambert and Larcker (2004) illustrate the leverage role that options provide over restricted stock even for risk-averse agents within the standard principal-agent model. As is common to the standard principal-agent model, however, their analysis does not consider the theoretical issues addressed in this paper with respect to the trade-off between options providing leverage in effort choice versus options distorting decision criteria. In particular, their analysis does not explore the optimal exercise price that arising out of this trade-off (as opposed to the cost of adding uncertainty to the agent's contract with a higher exercise price) nor the potential for knife-edge results that are consistent with the data.

[4] We adopt the natural context of project-selection similar to Lambert (1986). Other papers that have adopted a framework of project-selection and decision-making include Smith and Stulz (1985), Holmström and Ricarti-i-Costa (1986), Campbell et al. (1989), Smith and Watts (1992), Hirshleifer and Suh (1992), Bizjak et al. (1993), Core and Qian (2002), and Barron and Waddell (2003).

[5] Others have suggested a positive role of options that is robust to risk-neutral managerial preferences, but not in the context of decision-making. For instance, Haugen and Senbet (1981) show that options offer leverage that can mitigate the manager's propensity to consume nonpecuniary benefits. However, this leverage gain to options downplays the shareholder's challenge of motivating the manager to make appropriate decisions central to determining the value of the firm (also see Brown et al., 1991).

off that exists for the risk-neutral executive emerges with successive increases in the exercise price.

Section 2 presents a model that illustrates this trade-off in the principal's choice of the exercise price for options. Hall and Murphy (2000, p. 213) suggest that "if [risk neutral] managers valued stock options at their Black-Scholes value, the optimal granting policy would be to grant an infinite number of options at an infinite exercise price." In contrast, our analysis identifies a rationale for a finite optimal exercise price that does not rely on risk aversion on the part of executives. If one then considers a complete range of exogenous exercise prices, we also find a "knife-edge" result regarding the optimal use of options versus restricted stock. In particular, optimal equity-based compensation switches from almost all restricted stock to all stock options if the exercise price falls below a critical level. As all-option equity awards are common in practice, identifying conditions under which such practice is optimal is an appealing aspect of the theory.

Section 3 identifies rationale for limits in the use of options that arise if there are restrictions on the setting of the exercise price at-the-money. Such restrictions are consistent with the evidence we present for top executives and are in keeping with earlier research documenting that exercise prices are "nearly always set equal to the current stock price" (Hall and Murphy, 2000). We then show that firms may optimally introduce restricted stock into executives' compensations if exercise prices are constrained to be set at-the-money. In such cases, the restricted stock component of equity compensation acts to increase the executive's relative cost to accepting low-valued projects and thereby moves the agent's decision rule toward first-best, although at the expense of less evaluation effort.

Section 4 presents empirical regularities regarding the use of options, derived from an extensive dataset on executive compensation that covers the 1992–2003 period. Consistent with the theory, we find evidence in a pooled sample and, more significantly, in fixed-effect specifications, that more-important executives are less likely to have a given dollar of equity compensation awarded in the form of stock options. The reason why the fixed-effect results are particularly important is that they allow us to infer the effect of changes in the potential influence of individual executives on their equity compensation packages while controlling for all time-invariant unobserved heterogeneity. Our findings are consistent with our priors that as one becomes more important to the firm, the distortion effects of at-the-money stock options become more costly relative to the potential increase in effort associated with option use. We also interpret in the context of our theory the apparent tendency to use stock options over restricted stock in research-intensive environments, in smaller firms, and in firms that have not recently paid dividends. Section 5 contains concluding remarks.

2. Executive decision-making and equity-based compensation

The central role of top executives is to make decisions. Following Barron and Waddell (2003) and in the spirit of Lambert (1986), we adopt a simple model to highlight this role of the executive as a decision-maker. In this setting, the executive faces a choice between a "status quo" and a proposed alternative with a value that can be clarified through further investigatory effort. The value of the status quo is drawn from a distribution with density function h^{O} and expected future gross value to the firm of V^{O}. We model the payoff to the alternative as either "good" or "bad," with the realized values being drawn, respectively, from the density functions h^{G} and h^{B} with means V^{G} and V^{B}. We assume that the distributions of returns resulting from a good project, a bad project and the status quo are from the same family with identical variances but with means $V^B < V^O < V^G$. As such, a good outcome has a higher expected value than the status quo while a bad outcome has an expected value below the status quo. We denote the exogenous and known probability that the proposed alternative is good by $\alpha \in (0, 1)$.[6]

To capture the executive's influence on the quality of the signal on which decisions will be based, we assume the executive invests costly and unobservable effort, e, to increase the signal's precision. If the proposal is truly good, the signal, s, is drawn from a normal distribution with cumulative density function $F_G(s;e)$ with mean μ_G and precision $P(e)$. If the proposal is bad, the signal is drawn from normal distribution $F_B(s;e)$ with mean $\mu_B < \mu_G$ and precision $P(e)$. The fact that the executive can improve the quality of information is reflected by the assumption that the precision of the signal is increasing in executive effort, that is $\partial P/\partial e > 0$; in addition, we assume that precision increases at a decreasing rate, such that $\partial^2 P/\partial e^2 \leq 0$.

The process by which the executive converts information into a decision can be simply modeled as the executive's choice of a reservation signal, $\hat{s}$; the executive rejects the proposed alternative in favor of the status quo if and only if the signal observed by the executive is less than $\hat{s}$.[7] For a given evaluation effort and reservation signal, the executive rejects good proposals (a Type I error) with probability $F_G(\hat{s};e)$ and accepts bad proposals (a Type II error) with probability $1 - F_B(\hat{s};e)$. All else equal, adopting the terminology of Sah and Stiglitz (1988), an increase in $\hat{s}$ increases the likelihood of Type I error but reduces the likelihood of Type II error.

2.1. The first-best solution

To simplify our analysis, we focus on the effect of a single executive's decision on firm value, such that the expected future gross value to the shareholders can be written:

$$E[V(e, \hat{s})] = \alpha V^G + (1-\alpha)V^O - F_G(\hat{s}; e)L^I - (1 - F_B(\hat{s}; e))L^{II}, \qquad (1)$$

where $L^I = \alpha(V^G - V^O)$ and $L^{II} = (1-\alpha)(V^O - V^B)$ denote the expected losses from Type I and Type II errors. Eq. (1) illustrates that the best possible outcome is reduced by losses associated with both Type I and Type II errors.[8]

In the first-best solution, shareholders would direct the executive to improve the quality of information on which the decision is based up to the point where the margin gain to reducing Type I and Type II errors equaled the marginal effort costs. With respect to the criterion that translates the information gathered into a decision, shareholders would direct the executive to choose a reservation signal that equated any increase in expected loss that a higher reservation signal would induce through a Type I error with the associated decrease in expected loss from a Type II error. In that sense, the chosen reservation signal is very much dependent on the *relative* costs of errors while the effort choice is more dependent on the potential *magnitudes* of loss associated with errors.

[6] Note that our setup naturally implies that, if $0 < \alpha < 1$, the variance in the payoff to the alternative is greater than that of the status quo. However, this is not critical given our base-line assumption of risk-neutral agents.

[7] Further, we assume the signal-generating process yields well-behaved distributions, $F_G(s;e)$ and $F_B(s;e)$, such that the rule yielding a single reservation signal is optimal (see Milgrom, 1981).

[8] We assume that the costs of these errors are sufficiently large that it is not optimal for the principal to forego hiring the executive and take up a simple rule of either always rejecting or always accepting proposals.

2.2. The principal-agent problem

Kole (1997), Murphy (1999), and others note many differences between stock and options. For our purposes, the fundamental difference between the two types of equity is their implied exercise prices: zero for stock grants and strictly positive for option grants. To simplify our analysis, we therefore focus on this key distinction and abstract from others. Given this simplifying assumption, a single-period horizon, and a common one-period discount factor of $\rho \in (0, 1]$, the current value of the executive's compensation package takes the form

$$C = \delta + \rho(\beta^{R} V + \beta^{O} V^{O}), \tag{2}$$

where $V^{O} = \max(V - V^{E}, 0)$, with V^{E} denoting the "exercise value," the value of the firm above which options can be exercised for gain. Unlike restricted stock, the executive realizes increased wealth from stock options only if the firm's future value exceeds the exercise value, V^{E}. In (2), δ is the salary component of remuneration. The parameters β^{R} and β^{O} should be interpreted as the proportion of V, the firm's future value, and the proportion of V^{O}, the firm's value in excess of the predetermined exercise value, that the executive will acquire through the exercise of current-period grants of stock and stock options, respectively.

Even for the single-agent case, characterizing the optimal compensation package remains analytically difficult. One reason is that involved in the optimal compensation package is not only the choice of the weights for options and stock, but also the choice of the exercise value. In particular, in seeking to maximize the expected future value of the firm arising from decisions of the agent, the problem facing the principal is

$$\max_{\delta, \beta^{R}, \beta^{O}, V^{E}, e, \hat{s}} \rho E[V] - E[C], \tag{3}$$

subject to the agent's optimal choices of reservation signal and effort (the incentive compatibility constraints) and non-negativity constraints on δ, β^{R}, β^{O} and V^{E}.[9]

3. A simple illustration of the different effects of options

To provide insight into the nature of the solution to the above principal-agent problem, we start by considering the case of no prior equity holdings. This simplifies our discussion of the effect of option granting on the executive's choice of effort (Section 3.1) and of the executive's choice of a reservation signal (Section 3.2). Section 3.3 summarizes the firm's choice of the optimal exercise value. Section 3.4 considers the effect of prior equity holdings on the optimal compensation package. Section 3.5 considers the effect of an apparent constraint on the setting of the exercise value for options, and implications for option use across rank are identified in Section 3.6.

3.1. Increasing the exercise value leverages effort incentives

Table 1 presents an example of the expected payoffs to different compensation packages for an executive who faces a choice between the status quo and a proposed alternative with the same expected value. The alternative proposal is equally likely to be good or bad (i.e., $\alpha = 0.5$). For

[9] We further assume the executive's reservation utility level is sufficiently high such that, at the optimal contract, the agent's participation constraint is binding.

Table 1
Stock options and investments in information quality

Alternative compensation packages	Expected compensation if always accept status quo	Expected compensation if accept alternative when good signal indicates good project with probability			Expected loss in compensation from different types of errors		Increase in expected compensation to obtaining partial information over no information	Increase in expected compensation to obtaining full information over no information
		$p = 0.50$ (no information)	$p = 0.75$	$p = 1.00$ (full information)	Type I error (rejecting good alternative)	Type II error (accepting bad alternative)		
1 share of stock	50	50	52.5	55	10	10	***2.50***	***5.00***
2.5 options, exercise value of 30	50	50	56.25	62.5	10	10	***6.25***	***12.50***
15 options, exercise value of 50	50	62.5	81.25	100	6.67	3.33	***18.75***	***37.50***

Underlying payoffs (per share) are assumed to be 30, 40 and 50 (each with equal likelihood) when the alternative is a bad type, 40, 50 and 60 for the status quo, and 50, 60 and 70 when the alternative is a good type. The project is also assumed to be good or bad with equal likelihood (i.e., $\alpha = 1/2$).

clarity, we limit the status quo and each of the possible alternative outcomes to three potential payoffs that occur with equal probability. We also assume that the expected value of the status quo is equal to the initial market price of a share of stock ($50).

With probability p, a signal correctly indicates the project's type. For our example, we consider three levels of informativeness: no information ($p = 0.5$), partial information ($p = 0.75$), and full information ($p = 1$). As in the theory, the executive adopts the alternative proposal if the signal indicates a good project, and otherwise stays with the status quo. Across three compensation packages, Table 1 shows the expected compensation of the executive given differences in the informativeness of the signal regarding the type of the alternative project (good or bad). The three alternative packages differ only in exercise value and have the same expected value under the status quo: a single option with an exercise value of zero (i.e., a single share of stock), 2.5 options with exercise values of $30, and 15 options with exercise values equal to the current $50 market price of the stock.[10]

Table 1 reveals the leverage advantage of options in terms of the greater marginal gains to information gathering at higher exercise values. With an increase in the exercise value, the expected value of an individual option falls as the probability the option is unexercised increases; this falling unit-value enables the principal to leverage options into a larger number with every increase in V^E that increases the marginal return to effort, as illustrated in the last two columns of Table 1. That is, the increase in expected compensation to obtaining additional information increases as the exercise price increases. This induces an increase in the agent's effort level toward first-best.[11]

The example above also illustrates that it is appropriate to focus only on the potential leverage available in option awards as long as the exercise value is sufficiently low such that realizations of firm value below the exercise value are unlikely.[12] For instance, in our example, the equal-expected-value compensation of 2.5 options has an exercise value of 30, which does not exceed any potential realized share value. For such a contract, the executive thus has no bias towards adopting the alternative proposal, as the *relative* costs of Type I and Type II errors are identical to those of shareholders. For the package of 15 options with an exercise value of 50, however, the executive's costs of a Type II error are lower relative to a Type I error and illustrate that such a high exercise value induces a bias on the part of the executive toward adopting the alternative proposal. We discuss the implications of this bias in the next section.

3.2. *Increasing the exercise value distorts the decision-making criterion*

The example above illustrates that, beyond some point, an increase in the exercise value of options reduces the expected cost of a Type II error relative to the expected cost of a Type I error. The effect of such increases in the exercise value on the decision-making criterion is to induce the decision-maker to decrease the reservation signal. However, how shareholders value such an incentive depends on the degree to which the executive is risk-averse.

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[10] While simple and intuitive in its construction, this illustrates one dimension in which our example abstracts from the complexities underlying the agent's choices within the full model.

[11] Among others, Lambert (1986) and Core and Qian (2002) also model the executive's role in the firm as a decision-maker. However, this leverage gained through the influence of a higher exercise value on marginal efforts is not apparent in these papers because the executive's effort decision is framed as a zero/one choice: either perform no effort or perform a fixed, positive level of effort. Further, these papers provide no explicit role for the effect of changes in exercise values.

[12] More formally, the costs of Type I errors relative to Type II errors mirror shareholders for option holders with an exercise value below the lower bound of the distribution around bad proposals, h^B, which is $30 in the example of Table 1.

For the risk-neutral executive, replacing equity with options of equal-expected-value reduces the expected cost of a Type II error relative to the expected cost of a Type I error. This means that increases in the exercise value can induce the executive to favor lower standards of adoption than shareholders. For a risk-averse manager who holds a share of stock, the executive will initially choose a reservation signal above first-best to avoid the riskier payoff associated with adopting the proposed alternative. In this case, increasing the exercise value from zero (i.e., by converting stock into options) can improve the decision-making of the risk-averse executive, as it induces a decrease in the executive's reservation signal toward first-best.[13] However, such benefits to shareholders ultimately (and always) turn negative for sufficiently high exercise values.

3.3. The optimal exercise value: the trade-off of leverage and distortions

While options can lead to too low standards for project adoption, especially among risk-neutral agents, there remains the offsetting leverage gain to options: higher exercise values tend to encourage evaluation effort. Our simulation of the full model, reported in Barron and Waddell (2005), provides further insight into the nature of the trade-off implied by increasing the exercise value with non-degenerate distributions around outcomes and a richer characterization of the decision-maker's choices. Consistent with the simple example of Table 1, initial increases in the agent's level of effort that accompany increases in the exercise value reduce the probabilities of both Type I and Type II errors. In this way, options motivate strictly better decision-making, and the optimal compensation package will consist only of stock options. This feature of the model is particularly attractive in light of the empirical pattern of equity awards often being made exclusively as stock options. Ultimately, however, higher exercise values introduce significant distortion in the choosing of the reservation signal, biasing decisions toward acceptance and away from first-best. The optimal exercise value balances the marginal gain of a higher exercise value that increases effort with this marginal cost arising from a lower reservation signal.[14]

3.4. Prior equity holdings and the optimal compensation package

To account for the influence of prior stock and option holdings on the executive's choice of effort and reservation signal, let V_{-1} denote the value of the firm at the end of the prior period, let V_{-1}^{O} denote the "option value" of the firm at the end of the *prior* period, and let V^{OP} denote the option value of the firm at the end of the *current* period. The total anticipated change in the executive's wealth including current compensation is then of the form

$$\Delta W = C + \rho(\theta^{\mathrm{R}}(V - V_{-1}) + \theta^{\mathrm{O}}(V^{\mathrm{OP}} - V_{-1}^{\mathrm{O}})), \tag{4}$$

where V_{-1}^{E} is the exercise value attached to the options obtained in the prior period, $V^{\mathrm{OP}} = \max(V - V_{-1}^{\mathrm{E}}, 0)$ and $V_{-1}^{\mathrm{O}} = \max(V_{-1} - V_{-1}^{\mathrm{E}}, 0)$. Parameters θ^{R} and θ^{O} should be interpreted as the proportion of total firm appreciation (or depreciation) that the executive will realize privately

[13] The limiting case of exceedingly high risk aversion is uninteresting from a modeling perspective, as the agent merely rejects all proposed alternatives in favor of the status quo. We assume away such extreme preferences.

[14] This is formally demonstrated in Barron and Waddell (2005), where it is shown that at the optimal V^{E} the level of restricted stock grants is zero ($\beta^{\mathrm{R}} = 0$), such that all equity compensation is in the form of options. Of course, given the assumption of risk-neutrality, an important feature of this result is a binding non-negativity constraint on salary, such that the optimal salary component is zero ($\delta = 0$). Such a condition, when combined with a low value to the agent's reservation utility, removes the ability of the principal to effectively sell the firm to the agent.

from prior stock and option holdings, respectively. Setting $\theta^{R}=0$ and $\theta^{O}=0$ therefore yields the simpler model that does not account for the influence of prior equity holdings.

The strict dominance of options over stock in current compensation is robust to the introduction of prior equity holdings. However, the optimal current-period exercise value is influenced by prior holdings in two ways. First, the agent's equity holdings at the beginning of the period directly influence the marginal gain to any current-period investment in evaluation effort by the agent. Second, as revealed by our theory, the exercise values associated with inherited options influence the decision-maker's relative costs of Type I and Type II errors associated with current-period decisions.

Simulation results in Barron and Waddell (2005) reveal a very weak condition for whether prior holdings allow the principal to leverage current-period options more or less than would be the case in the absence of prior holdings. Namely, exercise values on prior option holdings that are lower (higher) than the otherwise-optimal current-period exercise value increase (decrease) the current-period optimal exercise value.

3.5. A constraint on exercise value and the optimal compensation package

In our sample of executives in the ExecuComp dataset between 1993 and 2003, over 96 percent of these awards made at-the-money.[15] In the context of our model, this suggests that V^{E} is not being freely chosen, as modeled, but rather reflects a near-universal rule for setting the exercise value equal to the grant-date market value of the firm's stock. Such a "rule-of-thumb" introduces a constraint on the choice of the exercise value.

There are at least two reasons to consider limits on the ability to offer in-the-money options. First, there are potential accounting and tax disadvantages to deviating from this rule-of-thumb.[16] Among others, Hall and Murphy (2000) suggest this possibility, noting that U.S. accounting rules "which require some accounting charges for discount options, help explain why exercise prices are seldom set below grant-date market prices" (p. 213). In addition, special Federal tax treatments exist for incentive stock options (ISOs). For "qualified" stock options, tax is deferred until the executive sells the stock. At that point, the entire option gain is taxed at long-term capital gains rates, provided the equity is sold at least 2 years after the option is granted and at least 1 year after exercised. ISOs are particularly attractive to top executives, who tend to benefit more than workers in lower income tax brackets from the capital gains treatment of ISOs. High-paid workers are also more likely than low-paid workers to be able to purchase shares at the exercise value and not sell through the required holding period to achieve capital gain taxation status. An important element of ISOs is that the options may not be granted at a discount to the stock's price, also placing a potential constraint to lowering the exercise value below the market value.

[15] This is consistent with the findings reported in Hall and Murphy (2000) and Smith and Zimmerman (1976). Hall and Murphy advance an economic rationale for the near-uniform practice of issuing options at the money within a framework for measuring the value and incentives provided by non-tradable stock options as opposed to traditional option pricing mechanisms. Resting largely on risk aversion, it is shown that "there is a fairly wide range of exercise pricing policies that yield close-to-optimal pay-to-performance incentives, and that this range typically includes grant-date market values" (p. 209). Recall that our approach assumes a risk-neutral agent, so is not directly comparable to the analysis of Hall and Murphy.

[16] In terms of the executive's incentives to invest in the evaluation of proposed plans of actions or to decide on a particular standard against which such a proposal will be measured, the key issue is that the exercise value is determined before the decision is made. In this context, the particular tax implications of awarding options in-the-money fall outside of the agent's optimization problem.

A second potential reason for an exercise price set differently from that predicted based only on effort and decision-making incentives is the growing evidence that individuals care not only about their own compensation package, but also with how it compares with others. Bolton and Ockenfels (2000) provide strong arguments that relative treatment matters to individuals and, in particular, that similar treatment is valued. In our context, we interpret this as introducing a "social reference point" of exercise prices being set at-the-money that may add a second component to the agent's utility function that is concave in the difference between the exercise price and the market price, reaching a maximum where the exercise price equals the market price. As a consequence, the principal can lower compensation costs by setting the exercise price equal to the market price even if doing so reduces the gross value of the project-selection process.

3.6. Executive rank and the use of options

We expect the effects of a fixed exercise value to differ across executive positions. For instance, consider the effect of a coincident increase in V^{G} and decrease in V^{B}, which increases the importance of decisions being made insofar as the decision has greater influence on firm value. These changes increase to the same degree the underlying costs to shareholders of Type I and Type II errors. However, for the option holder the increase in error costs is asymmetric, with a relatively larger increase in the cost of Type I error (rejecting a good project). In response, the unconstrained optimal exercise value will fall relative to the firm's current market value in order to maintain balance between the expected cost of decision-making bias and the leveraging gain associated with higher exercise values.

However, if the principal is constrained to set the exercise value at-the-money, then the principal's optimal response is to substitute restricted stock in place of stock options, resulting in a decrease in the proportion of equity-based compensation that is options. This suggests that when decisions carry the potential for greater upside and downside consequences, stock options are a less-favorable method of aligning executive interests with those of the shareholders. As such, we expect to see more use of restricted stock where decisions are of greater consequence to firm value.[17] Thus, we hypothesize the following:

Hypothesis 1. Where the principal is constrained to set the exercise value at-the-money, executives who make more-important decisions within their respective firms will be awarded a smaller proportion of equity compensation in the form of stock options.

4. Evidence regarding the use of restricted stock and stock options

Our simulations of the above model focus on linking attributes of the theoretical model to easily observed equity-based compensation characteristics, namely the proportion of equity compensation that is option-based.[18] The rationale for doing so is two-fold: the observed importance

[17] Recall that when unconstrained in the choice of exercise value, it is in the principal's best interest to compensate the risk-neutral agent only with stock options. One might think that if the exercise value was set above optimal, one could achieve equivalent first-best outcomes with some convex combination of options and stock. However, this is not the case. While such a replacement of options with stock can reduce the bias in the reservation signal induced by an exercise value that is set too high, it comes at the expense of lower effort due to the loss of the leveraging element of the replaced options.

[18] Others have also considered easily observed characteristics of compensation. For instance, Bryan et al. (2000) consider separately the size of stock awards and option awards relative to salary plus bonus compensation. The focus of our analysis

of equity-based compensation in the compensation packages of top executives (e.g., Yermack, 1995; Hall and Liebman, 1998; Core and Guay, 1999; Murphy, 1999; Aggarwal and Samwick, 2003; Barron and Waddell, 2003) and the noted different incentive effects of these two types of equity-based awards that are sometimes overlooked.

To examine the composition of equity compensation among executives, we rely on the S&P ExecuComp dataset. Recorded directly from proxy statements, this dataset contains details on the compensation of the top-five executives of publicly traded companies in the S&P 500, S&P MidCap 400 and S&P SmallCap 600 for the years 1992 through 2003. Limiting our attention to top-five executives who receive equity compensation yields a sample of over 93,000 executive-year observations, reflecting the compensation of the top-five executives at approximately 1700 firms each year.[19] Over this 11-year period, there was an increased use of equity-based compensation, with over 80 percent of top executives in 2003 receiving some compensation that is equity-based. Further, during this period approximately 74 percent of equity-based compensation packages were solely options. This provides some support for the clear advantage of options predicted by the theory.

4.1. Decision importance and the use of options

Our theoretical discussion established a hypothesis linking the proportion of equity-based options to the importance of the decisions being made. As there is no formally prescribed notion of how one might capture differences in the relative importance of decisions made by different executives in our sample, we report results across a variety of measures. In the end, results are largely robust to these alternatives.

One measure we consider is an ordinal ranking of executives at a firm based on total annual compensation. A second is an ordinal ranking that forces the reported CEO to hold the top position within the firm and then ranks other executives by total compensation. A third measure of the relative importance of the decisions made by an executive, first used in Barron and Waddell (2003), equals the logged ratio of the executive's total compensation to the highest total compensation reported at the executive's firm in the same year. The presumption is that the greater the difference in the compensation levels across executives at the same firm, the greater the difference in the nature and/or importance of projects being evaluated by these individuals.[20]

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differs from theirs in that we examine determinants of the ratio of option compensation to total equity-based compensation. We also provide a direct link between the theory and our empirical measure of the equity-compensation mix.

[19] The ExecuComp dataset includes reports by some companies of compensation beyond the five highest paid mandated by SEC disclosure requirements. We limit our analysis to the top-five to eliminate potential sample-selection bias driven by over-reporting. Barron and Waddell (2003) provide further details on the identification of the top-five executives at each firm.

[20] In the vast majority of cases, the highest compensation in a given year is that of the firm's CEO. In constructing our measure of executive importance, we adjust for cases when an executive is in his or her last or first year at the firm and thus likely has compensation that reflects a partial year. In such cases, if it is the top executive, if the departing executive's compensation is below the compensation in the prior year or the new executive's compensation is below compensation in the subsequent years, and if the executive has the same title in both years, then we identify the compensation for the top position at the firm using the individual's prior or subsequent year compensation. For executives filling positions other than the top position who are in either their last or first year at the firm, if the ratio is lower in their last or first year, respectively, and there is no change in the title of their position across the 2 years, then we replace the ratio of their compensation to the top executive's with the one in the prior year for a departing executive or with the ratio in the subsequent year for a new executive.

4.2. Control variables

As controls, we included a number of other variables that could influence the proportion of equity-based compensation that is options. Many of these variables have also been suggested in analyses that focus on pay-for-performance sensitivity. In particular, we include measures of firm size (log of total assets), the importance of research and development (ratio of R&D expenditures to assets), past dividend payments (whether dividends were paid in the prior period), a market return-volatility measure, a set of indicator variables capturing the two-digit NAICS industry of the firm, and a trend variable. These data are summarized in Table 2.

The theory developed in Section 3 indicates that the level and character of prior holdings of stock and stock options can also affect the optimal form of current compensation.[21] As equity can be held in two different forms (stock and unexercised options) that differ in their influence on marginal returns to effort and decision bias, we include separate controls for the values of stock and unexercised options. As proxy statements report only the aggregate number of options and the aggregate intrinsic value of previously awarded options that are in-the-money, we follow Murphy (1999) in treating all existing options as a single grant with a 5-year remaining term and an exercise price such that the intrinsic value is equal to that reported in the proxy statement. We then impute a Black-Scholes value for existing options using the dividend yield for the company reported in ExecuComp and the standard deviation of monthly stock returns for each company using monthly total returns to shareholders over the 60 months preceding each sample year using data from the Center for Research in Security Prices (CRSP).[22]

Of course, the underlying exercise prices of options inherited from prior periods also influences the decision-maker's relative costs of Type I and Type II errors. To create a measure of the effective exercise price on existing stock options, and thus the degree to which an executive's relative costs of Type I and Type II errors may differ from that of shareholders, we first calculate the average intrinsic value of inherited options. This average intrinsic value is equal to the total intrinsic value of the executive's option holdings (zero for under-water options and increasingly positive for options that are increasingly in-the-money) divided by the number of options held. We then compute the ratio of this average intrinsic value of option holdings to the firm's current stock price. The higher this ratio is (which approaches one in the limit), the more stock-like (i.e., in-the-money) are inherited options and the lower are expected costs of Type I errors relative to Type II errors. In this case, the optimal exercise value on new options is higher to take advantage of the leveraging characteristic of options. On the other hand, when this ratio is low (i.e., approaching zero), inherited options are more option-like and the expected costs of Type I errors are higher relative to Type II errors. In this case, the optimal exercise value is lower to offset the decision-making bias induced by the inherited options. Because this ratio cannot be computed when the executive holds no options at the beginning of the period, we set the ratio equal to zero in such cases and include an indicator variable to capture any difference in option use for such executives.

[21] Others have also noted the importance of prior holdings in affecting the incentives of the executive (e.g., Jensen and Murphy, 1990; Hall and Liebman, 1998; Aggarwal and Samwick, 1999; Abowd and Kaplan, 1999), albeit not the exact role they play in altering incentives in our decision-making environment.

[22] Given our assumption of risk neutrality, we avoid the inconsistency recognized by Hall and Murphy (2000), who note that the application of market-based valuation formulas such as Black-Scholes do not capture managerial incentives provided by option compensation when executives are risk-averse.

Table 2
Variable definitions and summary statistics

Variable	Units	Definition (source)	Mean (S.D.)
Proportional rank	Ratio	Ratio of each executive's total compensation to the top executive's compensation at the firm in the same year (ExecuComp)	0.587 (0.301)
Value of executive's prior option holdings	Millions dollars	Imputed Black-Scholes value of options held in millions of 1999 dollars (ExecuComp)[a]	0.00714 (0.031)
Value of executive's prior stock holdings	Millions dollars	Value of stock held in millions of 1999 dollars (ExecuComp)	0.01558 (0.172)
Extent to which prior option holdings are "stock-like"	Ratio	Ratio of the average in-the-money value of all-option holdings to the stock price; ranges from zero to one, and provides a measure of the extent prior options are like stock (ExecuComp)	0.272 (0.234)
Executive does not have prior option holdings	0, 1	Indicator that individual's prior holdings of equity does not include options (ExecuComp)	0.052 (0.222)
Firm book value of assets	Millions dollars	Book value of physical plant, inventories, and investments in unconsolidated subsidiaries in millions of 1999 dollars (ExecuComp)	10,579 (43,214)
Ratio of R&D expenditure to book value of assets	Ratio	Ratio of research and development expenditures to book value of assets, both in 1999 dollars (Compustat)	0.030 (0.073)
Firm paid dividend in prior year	0, 1	Indicator that firm paid dividend in preceding fiscal year (ExecuComp)	0.600 (0.490)
S&P 500 60-month return volatility		Standard deviation in the overall monthly return for S&P 500 firms over the previous 60 months (CRSP)	0.039 (0.009)
Firm industry indicators	0, 1	Indicator variables: two-digit North American Industry Classification System industries (Compustat)	

Sample of top-five executives from ExecuComp for the years 1993–2003. Statistics for the sample of 54,885 executive-year observations for which equity was granted to the executive. Sample corresponds to results reported in columns 2 and 3 of Table 4 and represent up to the 55,336 top-five executives across 2518 firms over the period 1993–2003.

[a] As proxy statements report only the aggregate number of options and the aggregate intrinsic value of previously awarded options that are in-the-money, we follow Murphy (1999) in treating all existing options as a single grant with a 5-year remaining term and an exercise price such that the intrinsic value is equal to that reported in the proxy statement. In this computation, we use 10-year Treasury bond rates as the risk-free rates of return. These risk-free interest rates for 1992 through 2003 are 7.01, 5.87, 7.09, 6.57, 6.44, 6.35, 5.26, 5.65, 6.03, 5.02, 4.61, and 4.01 percent.

4.3. Pooled-sample estimation results on rank

While our theory has focused on the optimal use of options as a proportion of total equity-based compensation, using the measured proportion as a dependent variable introduces potential econometric problems as this variable is bounded in the unit interval. Such boundedness implies that the assumption of a normally distributed error term is not tenable. As such, we adopt the generalized linear model (GLM) methodology introduced in Papke and Wooldridge (1996), which handles both the boundedness and lumpiness of the dependent variable's distribution. Table 3 reports the results of an empirical test of the above hypothesis using a pooled panel of executives. As predicted by our theory, across all specifications we find that more-important executives receive proportionately less equity in the form of stock options.[23]

In view of our theory, proportionately lower stock-option usage for more-senior executives is consistent with the conjecture that executives at different levels face systematic differences in the types of proposals received, with more-senior executives evaluating projects of greater consequence to firm value. The estimates of column (1) suggest that in a specification that constrains the estimated effect of a unit-difference in ordinal ranking to be constant across all ranks, the estimated proportion of equity received as options falls by roughly half a percentage point with each difference in ordinal rank. Allowing the estimated coefficient to differ across rank (as in column (2)) yields a slightly richer story, with differences of 0.7 percent points between second and third ranks and differences of 0.3 percent points between first and second ranks. Replacing the top-ranking executive with the CEO where the CEO was not the highest paid executive (i.e., columns (4) through (6)) also suggests that option use declines with importance, with column (2) and column (5) estimates implying similar marginal differences.

For both ordinal rank measures, a close examination of the data reveals variation in ordinal rankings that one might reasonably argue is not due to underlying variation in importance. For example, an executive might exhibit rankings of $r_{1998} = 2$, $r_{1999} = 1$, and $r_{2000} = 2$ over a 3-year period. To consider whether such occurrences predict variation in option-granting differently from a more stable or expected pattern, columns (3) and (6) repeat the estimation procedures allowing for different coefficient estimates according to whether an executive bounces in and out of the top position in the firm over a 3-year period. In the case of column (6) this amounts to an executive bouncing in and out of the CEO position over a 3-year period. Relaxing the model in such a way reveals two regularities across our specifications. First, the point estimates for the group of executives who are "stable" in their top-ranking become more negative. Second, those who are "unstable" (in and out of the top position within 1 year) are different. We therefore believe that separating such individuals from the pool of top executives is appropriate. We hesitate in placing too much importance on the point estimates for such individuals, however, as explaining away such differences requires explanation of interim periods of high compensation, which lies beyond the scope of this paper.

In Table 3, column (7) adopts the proportional ranking measure that directly exploits the cardinal information contained in observed compensation. All in all, the results using the alternative ranking schemes demonstrates the robustness of the importance of rank on the make-up of equity compensation in the analysis of the cross-sectional variation in option usage.

4.4. Discussion of control variables

The results reported in Table 3 indicate that firm size is an important determinant of the use of stock options. Executives at larger firms, although they receive proportionately more equity-based compensation (Barron and Waddell, 2003), tend to receive less equity in the form of options. One way to interpret firm size is as a reflection of the magnitude of any decision's impact on firm value,

[23] While not reported, including controls for re-pricing of options or for a 1 million dollar "cap" on cash compensation each leave the results unchanged.

Table 3
Executive rank and option-based equity compensation

Independent variable	Executives ranked by total compensation (1)	(2)	(3)	Executives ranked by CEO, followed by total compensation (4)	(5)	(6)	Proportional rank (7)
Continuous ranking[a]	−0.044 (3.71)***			−0.041 (3.50)***			−0.191 (3.45)***
Rank 1 (top)		−0.174 (3.41)***			−0.151 (2.94)***		
Stable rank 1			−0.190 (3.57)***			−0.157 (3.03)***	
Unstable rank 1			−0.044 (0.55)			0.742 (1.83)*	
Rank 2		−0.111 (2.33)**	−0.112 (2.33)**		−0.134 (2.82)***	−0.134 (2.82)***	
Rank 3		−0.082 (1.82)*	−0.083 (1.83)*		−0.081 (1.81)*	−0.082 (1.81)*	
Rank 4		−0.031 (0.72)	−0.031 (0.72)		−0.020 (0.47)	−0.020 (0.47)	
Log of firm book value of assets	−0.107 (8.66)***	−0.107 (8.65)***	−0.107 (8.64)***	−0.107 (8.67)***	−0.107 (8.66)***	−0.106 (8.62)***	−0.108 (8.70)***
Ratio of R&D expenditure to book value of assets	4.951 (8.17)***	4.950 (8.17)***	4.939 (8.15)***	4.949 (8.17)***	4.950 (8.17)***	4.948 (8.17)***	4.958 (8.18)***
Firm paid dividend in prior year	−0.669 (15.05)***	−0.669 (15.05)***	−0.667 (15.00)***	−0.668 (15.03)***	−0.668 (15.03)***	−0.666 (14.99)***	−0.668 (15.00)***
S&P 500 60-month return volatility	−10.035 (5.41)***	−10.035 (5.41)***	−10.113 (5.45)***	−10.041 (5.42)***	−10.040 (5.42)***	−10.082 (5.44)***	−9.982 (5.39)***
Trend (1992 = 1)	−0.017 (2.95)***	−0.017 (2.95)***	−0.017 (2.96)***	−0.017 (2.95)***	−0.017 (2.95)***	−0.017 (2.90)***	−0.018 (3.08)***
Value of prior option holdings[b]	2.459 (1.43)	2.495 (1.44)	2.559 (1.45)	2.445 (1.44)	2.410 (1.42)	2.429 (1.42)	2.518 (1.44)
Value of prior stock holdings	0.110 (0.68)	0.112 (0.68)	0.112 (0.68)	0.116 (0.71)	0.112 (0.69)	0.114 (0.70)	0.117 (0.71)
Extent to which prior option holdings are "stock-like"[c]	0.680 (7.70)***	0.680 (7.69)***	0.680 (7.68)***	0.679 (7.70)***	0.680 (7.70)***	0.680 (7.70)***	0.679 (7.68)***
Executive does not have prior option holdings	−1.251 (20.39)***	−1.251 (20.37)***	−1.256 (20.40)***	−1.252 (20.40)***	−1.251 (20.39)***	−1.257 (20.44)***	−1.245 (20.32)***
NAICS industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	3.429 (28.68)***	3.640 (29.59)***	3.644 (29.56)***	3.434 (28.71)***	3.635 (29.66)***	3.629 (29.62)***	3.670 (29.01)***
Executive-year observations	55336	55336	55336	55336	55336	55336	55336
Log pseudo-likelihood	−18115.70	−18115.52	−18114.01	−18116.72	−18116.06	−18113.11	−18116.41

In all specifications, the sample consists of top-five executives from ExecuComp for the years 1993–2003, with a dependent variable equal to the proportion of the executive's annual equity compensation awarded through stock options. Reported coefficients are derived from a generalized linear model with a dependent variable distributed binomial and a logit link function. All models assume that observations need not be independent across a given executive's years at the same firm. Absolute values of *t*-statistics are in parentheses. Coefficients for industry indicator variables are available from the authors.

[a] Rank is defined as −1 (top) through −5 (bottom) in columns (1) through (6) and as the logged ratio of the executive's total compensation to the highest total compensation at the executive's firm in the same year in column (7).

[b] We follow Murphy (1999) in imputing the Black-Scholes value of existing stock options.

[c] Ratio of the average value of all in-the-money option holdings to the firm's stock price; ranges from zero to one, and provides a measure of the extent prior options are like stock (ExecuComp).

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

with executives at larger firms facing larger consequences to adopting new projects. Adopting this view, an executive at a larger firm is rather like a more-influential executive at a smaller firm and might therefore receive fewer options and more restricted stock.

Firms with greater R&D expenditures are more likely to receive a given dollar of equity compensation as stock option.[24] Financial accounting standard's classification of research and development expenditures suggests that the magnitude of R&D expenditures can serve to indicate the extent to which executive decisions involve new product development. New product development often involves a lengthy time interval until the product reaches the market, and this can introduce substantial uncertainty at the outset with regard to the value of a proposed plan. In the context of our model, such an increase in uncertainty regarding plan type may be interpreted as increasing the variance of the signal on project type for a given evaluation effort by the executive, thus raising the marginal gain from increased evaluation effort in terms of reducing signal variance.

We also find that paying dividends is associated with lower weight on stock options. One way to interpret this result in the context of our model is that the likelihood an at-the-money constraint is binding is higher if potential future returns are paid out as dividends rather than retained and thus not reflected by an appreciation in the price of the firm's stock. An exercise price set equal to the current market price will be higher relative to the future market price of the firm if the firm has a policy of paying dividends. As such, dividend payments increase the likelihood that an at-the-money exercise price is higher than optimal.[25]

Including our measures of prior equity holding, the data do reveal that when inherited options have low exercise prices relative to the market price, an executive is more likely to have a given dollar of equity compensation awarded in the form of stock options. This is an expected result, as the theory suggests that when inherited stock options are more stock-like, the relative costs of errors for the decision-maker are more-closely aligned with those of shareholders, which increases the optimal exercise value as the firm attempts to leverage options into higher effort. This makes it less likely that a rule-of-thumb constraint equating the exercise value to the market price will lead the principal to substitute restricted stock for options. Note that when the executive holds no options at the beginning of the period, options are less likely to be granted in the current period, suggesting that this variable may be picking up executive-specific factors that are negatively correlated with the use of options and not captured by the other variables.

4.5. Nonconformity to standard exercise-value practices and the use of options

Our theory suggests that stock options are less likely to be used if the rule-of-thumb of setting $V^E = V^C$ results in an exercise value set too high. It follows that if $V^E < V^C$ (i.e., in-the-money), then such cases in particular should be ones where the adjustment of the exercise price enhances the use of options. Columns (1), (3) and (5) of Table 4 report the results of the previous specification

[24] There is a drop in the size of the R&D coefficient when the sample is constrained to those who receive stock options. This is consistent with research intensity driving the existence of equity as in Barron and Waddell (2003), as confirmed by estimates from a Heckman two-stage procedure controlling for the selection of equity compensation in the first stage (not reported). The use of a Heckman specification is not justified for our data by a likelihood ratio test.

[25] Our view is that a reduced reliance in the past on dividends, by indicating a lower future propensity to pay dividends, helps to explain an increased use of options. This view contrasts with Lambert et al. (1989) and, more recently, Fenn and Liang (2001). These authors reverse the causation and suggest that the use of stock options today may help to explain a reduced reliance on dividends in the future.

Table 4
Executive rank and option-based equity compensation: deviations from at-the-money

Independent variable	Executives ranked by total compensation (1)	(2)	Executives ranked by CEO, followed by total compensation (3)	(4)	Proportional rank (5)	(6)
Continuous ranking[a]					−0.137 (2.28)**	−0.141 (2.34)**
Stable rank 1	−0.220 (3.91)***	−0.221 (3.92)***	−0.196 (3.58)***	−0.198 (3.61)***		
Unstable rank 1	−0.209 (2.54)**	−0.222 (2.70)***	0.104 (0.25)	0.089 (0.21)		
Rank 2	−0.155 (3.08)***	−0.155 (3.08)***	−0.194 (3.88)***	−0.194 (3.89)***		
Rank 3	−0.138 (2.92)***	−0.137 (2.90)***	−0.143 (3.03)***	−0.143 (3.02)***		
Rank 4	−0.036 (0.81)	−0.035 (0.79)	−0.047 (1.04)	−0.046 (1.02)		
Executive received stock options in-the-money		1.249 (6.57)***		1.248 (6.57)***		1.251 (6.60)***
Executive received stock options out-of-the-money		0.380 (2.89)***		0.378 (2.88)***		0.374 (2.84)***
Constant	4.398 (33.96)***	4.347 (33.45)***	4.395 (34.00)***	4.345 (33.48)***	4.341 (33.62)***	4.294 (32.53)***
Executive-year observations	52361	52361	52361	52361	52361	52361
Log pseudo-likelihood	−12418.94	−12398.83	−12419.33	−12399.28	−12426.71	−12406.64

In all specifications, the sample consists of top-five executives from ExecuComp for the years 1993–2003, with a dependent variable equal to the proportion of the executive's annual equity compensation awarded through stock options. Reported coefficients are derived from a generalized linear model with a dependent variable distributed binomial and a logit link function. All models assume that observations need not be independent across a given executive's years at the same firm. Absolute values of *t*-statistics are in parentheses. Coefficients for industry indicator variables are available from the authors. We include all variables listed in Table 3 in the estimation, but do not report some of the coefficients for brevity. We follow Murphy (1999) in imputing the Black-Scholes value of existing stock options. Ratio of the average value of all in-the-money option holdings to the firm's stock price; ranges from zero to one, and provides a measure of the extent prior options are like stock (ExecuComp).

[a] In columns (5) and (6), rank is defined as the logged ratio of the executive's total compensation to the highest total compensation at the executive's firm in the same year.

** Significant at 5 percent level.

*** Significant at 1 percent level.

with the addition of a measure of how exercise prices are set for each executive.[26] As expected, we find that the awarding of in-the-money options increases the likelihood that a given dollar of equity-based compensation is awarded as stock options.

Somewhat surprisingly, we also find evidence that nonconformity alone in setting the exercise price encourages the use of options, as there is an increase in the likelihood that a given dollar of equity-based compensation is awarded as stock options when the exercise price is out-of-the-money, although by less than if the awarded options were in-the-money. We view these findings as generally supportive for our theory that options will be more widely used when there is flexibility in setting the exercise value and, in particular, when the exercise price might otherwise be set too high.

4.6. Controlling for executive fixed effects

Our cross-sectional evidence of proportionately less stock-option compensation at more-senior positions is consistent with the conjecture that more-senior executives make decisions that have greater consequences with respect to firm value. However, given other evidence that cross-sectional differences in managerial ability or human capital are important determinants of compensation (e.g., Prendergast, 1996), the finding that more-senior positions are associated with less stock-option compensation may be driven by cross-sectional variation. For example, if the more-senior executives in a cross-section are also those who tend to realize less disutility from uncertainty, risk aversion might explain the pattern of option use across rank.

Maintaining our interest in explaining empirical regularities without appealing to risk, we therefore estimate a similarly specified model that includes executive fixed effects. In particular, Table 5 reports the results, results that control for all time-invariant factors that are specific to each executive-firm pairing. As such, the error structure absorbs any individual effects (e.g., risk preferences) that explain average differences in the structure of equity compensation across individual executives. While addressing the competing hypothesis of risk aversion is our most immediate concern, we also note that other executive-specific heterogeneity that tends not to vary with time (e.g., effort aversion, productivity, gender, education) is also absorbed by the fixed-effect specification. In all cases, we allow each executive's fixed effect to differ by firm if the executive is observed at multiple firms, allowing for these time-invariant characteristics to interact with firm-specific characteristics differently.

As in previous specifications, our dependent variable lies in the unit interval. In our cross-sectional analysis, we adopted the GLM procedures of Papke and Wooldridge. However, in a fixed-effect specification, such is not available. We therefore transform the dependent variable into a log-odds ratio, $\ln(y/(1-y))$, that has a conditional expectation that is linear in right-hand-side variables and can be handled straightforwardly in a fixed-effects specification. Of course, while this is an accepted method for controlling for the boundedness of the dependent variable, any mass at the end points of the distribution (i.e., no options awarded and only options awarded) must be accounted for. We therefore follow standard practice in replacing observed end-points values with approximations (i.e., replacing zeros with 0.00001 and ones with 0.99999). Given

[26] As this information exists only where options are awarded, inclusion in the sample is conditional on the executive receiving some strictly positive proportion of equity in the form of stock options in that year. Our results are not sensitive to this change in sample size.

Table 5
Option-based equity compensation and changes in an executive's rank

	Executives ranked by total compensation		Executives ranked by CEO, followed by total compensation		Proportional rank
Independent variable	(1)	(2)	(3)	(4)	(5)
Continuous ranking[a]	−0.147 (4.75)***		−0.116 (3.53)***		−1.074 (7.22)***
Stable rank 1		−0.514 (3.53)***		−0.416 (2.67)***	
Unstable rank 1		−0.765 (4.30)***		−0.430 (0.72)	
Rank 2		−0.364 (3.23)***		−0.376 (3.34)***	
Rank 3		−0.191 (1.86)*		−0.156 (1.53)	
Rank 4		−0.066 (0.68)		−0.051 (0.52)	
Executive-firm fixed effect	Yes	Yes	Yes	Yes	Yes
Constant	8.021 (14.60)***	8.691 (15.60)***	8.079 (14.70)***	8.625 (15.45)***	9.162 (16.38)***
Executive-year observations	55336	55336	55336	55336	55336
Executive-firm combinations	17738	17738	17738	17738	17738
	$F(10, 37{,}588) = 18.03$	$F(14, 37{,}584) = 13.17$	$F(10, 37{,}588) = 17.02$	$F(14, 37{,}584) = 12.39$	$F(10, 37{,}588) = 21.00$

In all specifications, the sample consists of top-five executives from ExecuComp for the years 1993–2003, with a dependent variable equal to the proportion of the executive's annual equity compensation awarded through stock options. As the proportion of equity granted as stock options is necessarily in [0, 1], the dependent variable is transformed to the log-odds ratio, with end points replaced with approximations (i.e., with 0.00001 and 0.99999). In all specifications we control for unobserved heterogeneity specific to each executive-firm combinations. Absolute values of *t*-statistics are in parentheses. We include all variables listed in Table 3 in the estimation, but do not report some of the coefficients for brevity. We follow Murphy (1999) in imputing the Black-Scholes value of existing stock options. Ratio of the average value of all in-the-money option holdings to the firm's stock price; ranges from zero to one, and provides a measure of the extent prior options are like stock (ExecuComp).

[a] Rank is defined as −1 (top) through −5 (bottom) in columns (1) through (6) and as the logged ratio of the executive's total compensation to the highest total compensation at the executive's firm in the same year in column (7).

* Significant at 10 percent level.

*** Significant at 1 percent level.

this approximation, we first confirm the robustness of the earlier cross-sectional results to this alternative specification.[27]

As indicated in Table 5, the estimation results of a fixed-effect model that controls for unobserved effects specific to each executive-firm combination confirms that the option proportion of equity compensation decreases for an individual executive who becomes more important to the firm, as measured by time-series variation in rank. These fixed-effect results provide support for our view that the importance of decisions, and the related asymmetries in the costs of Type I and Type II errors when options are offered, provide insights into the use of options.

4.7. Exploiting reported titles to indicate decision importance

Before concluding our analysis, we consider the potential within the data to exploit yet another alternative specification of the relationship between option use and the importance to firm value of the decisions facing the executive that derives from the titles of the position held. In particular, following Aggarwal and Samwick (2003), we consider three categories based on declining importance in terms of their potential effect on firm value. As Aggarwal and Samwick (2003, p. 1618) note, "the job title reported for each executive in ExecuComp is up to 30 characters in length and corresponds most closely to the title reported by the firm in the summary compensation table of its DEF 14A filing to the SEC." The first group defines chief executive officers, who are likely to have the most influence on firm value within the firm.[28] The second group of executives defines those other than CEOs who have oversight authority, such as presidents, chairmen, vice-chairmen, chief financial officers and other c-level executives. The third group consists of those not in the first two groups who are listed as division heads. For example, the four most common titles among this group are executive vice-president, senior vice-president, senior vice-president and general counsel, senior vice-president-operations. Excluded from this analysis are all other executives. This includes not only executives for whom official titles are not provided but also executives whose title suggests decisions more likely to be tangential to the determination of firm value.[29]

Table 6 provides a summary of the number of observations within each of the three groups identified though position titles as holding key positions at the firm in terms of their influ-

[27] In fact, the qualitative results reported are robust to several treatments. For example, rephrasing the question to take the form "What determines the likelihood that a given dollar of equity compensation is option-based?" a weighted-Probit technique that handles both the unit interval and the lumpiness of the proportional data yields similar results. We also get qualitatively similar results using simple proportions as the dependent variable, when adopting a Tobit estimation procedure where the boundedness is treated as though the data are both left- and right-censored, or an ordered Logit model where the observed proportions are grouped into mutually exclusive intervals and thereby into an ordinal approximation of the underlying data. Finally, a Heckman specification to control for the use of stock options is not justified by a likelihood ratio test.

[28] We identify CEOs first by the executive identified as the CEO by ExecuComp. Where no CEO is reported, we rely on reported titles to identify the CEO, making note that there are variety of ways that the same title can be expressed (e.g., CEO, or Chief Executive Officer, or CHIEF EXEC OFFICR, as well the potential for abbreviations of these terms). As such, we also permit multiple CEOs in a given year (e.g., Co-CEOs).

[29] For those in this group with titles, as in Aggarwal and Samwick (2003), it appears that this group is largely populated by those who have neither explicit divisional responsibility nor primary oversight authority, such as vice-president, general counsel, group vice-president and vice-president-operations. Note that this ranking of influence on firm value based on position titles is consistent with the finding that the three ranked groups have higher equity-based compensation as a proportion of total compensation than those omitted from the analysis. In addition, within the three groups identified as having significant influence on firm value, a move up in position in terms of perceived potential to influence firm value is accompanied by an increase in the proportion of compensation that is equity-based. A similar result based on compensation rank (not titles) is reported in Barron and Waddell (2003).

Table 6
Title- or position-based ranking and option-based equity compensation[a]

Independent variable	Replicating Table 3(7)		Replicating Table 4(6)		Replicating Table 5(5)	
	Proportional rank[b] (1)	Title rank[c] (2)	Proportional rank[b] (3)	Title rank[c] (4)	Proportional rank[b] (5)	Title rank[c] (6)
Rank	−0.244 (4.19)***	−0.063 (2.70)***	−0.186 (2.94)***	−0.051 (2.04)**	−1.240 (7.57)***	−0.148 (1.67)*
Executive-year observations	46576	46576	44145	44145	46576	46576
Log pseudo-likelihood/F-statistic	−15408.0	−15415.4	−10726.4	−10729.0	$F(10, 31{,}357) = 23.62$	$F(10, 31{,}357) = 18.13$

In all specifications, the sample consists of all c-level executives from ExecuComp for the years 1993–2003, both those with oversight authority and those without oversight authority but listed as division heads. The dependent variable is equal to the proportion of the executive's annual equity compensation awarded through stock options.

[a] All specifications include the log of firm book value of assets, the ratio of R&D expenditure to book value of assets, dividends paid, the S&P 500 60-month return volatility, trend (1992 = 1), value of prior option holdings, value of prior stock holdings, the extent to which prior option holdings are "stock-like", and a control for whether the executive does not have prior option holdings. In pooled samples, we also include industry indicators. Columns (1) through (4) report coefficients derived from a generalized linear model with a dependent variable distributed binomial and a logit link function. Columns (5) and (6) report coefficients that are estimated controlling for unobserved heterogeneity specific to all executive-firm combinations. As the proportion of equity granted as stock options is necessarily in [0, 1], the dependent variable is transformed to the log-odds ratio. End points in the distribution of the dependent variable are replaced with approximations (i.e., replacing zeros with 0.00001 and ones with 0.99999). Absolute values of t-statistics are in parentheses.

[b] Proportional rank is defined as the logged ratio of the executive's total compensation to the highest total compensation at the executive's firm in the same year. Title rank is defined as CEO (rank = −1), those who have oversight authority (e.g., presidents, chairmen, vice-chairmen, chief financial officers and other c-level executives) (rank = −2) and those who are listed as division heads, without oversight authority (rank = −3).

[c] The first group (rank = −1) defines chief executive officers, who are likely to have the most influence on firm value within the firm. The second group of executives (rank = −2) defines those other than CEOs who have oversight authority, such as presidents, chairmen, vice-chairmen, chief financial officers and other c-level executives. The third group (rank = −3) consists of those not in the first two groups who are listed as division heads. For example, the four most common titles among this group are executive vice-president, senior vice-president, senior vice-president and general counsel, senior vice-president-operations.

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

ence on firm value. Note that these three key groups cover 46,576 of the 55,336 observations used in Table 5: 28.7 percent are in the top category, 41.7 percent are in the second category (having "oversight responsibility"), and 29.6 percent are in the third category (being "division heads"). For this alternative sample based on position title, Table 6 replicates earlier specifications and then introduces our position- or title-based measure of importance. Several findings are of interest.

First, across both pooled and fixed-effect specification, the regularities initially identified for the entire sample are universally stronger upon discarding those executives without at least divisional responsibilities, as shown in columns (1), (3) and (5) (which replicate column (7) of Table 3, column (6) of Table 4 and column (5) of Table 5, respectively). Second, adopting a position-based ranking again confirms the theoretical prediction of less option use at higher ranks or at positions where decision-making is likely to have larger influence on firm value. In particular, exploiting only time-series variation in each individual executive's position across the three classifications discussed above, column (6) of Table 6 reaffirms that as individual executives are promoted, their equity compensation becomes less option heavy.[30] We interpret this empirical regularity as a systematic response to the increasing influence the executive will have on firm value and the accompanying increase in the value to having decision criteria chosen appropriately relative to having highly leveraged effort.

5. Conclusion

The model of decision-making developed in this paper highlights a key benefit to compensating executives with options. By leveraging a given expected compensation in the form of stock into a larger number of stock options, option compensation provides the agent greater incentives to determine the true value of the plan being proposed. This is novel as it does not rely on risk considerations to identify a positive role for stock options in optimal equity-based compensation packages. However, if there is a binding constraint to reducing the exercise price to its optimal level, then the leverage value of options can be outweighed by the costs associated with options inducing distortions. In such cases, firms will find it optimal to award some compensation in the form of stock grants to realign the executive's interests with those of shareholders by increasing the executive's concern for losses at the margin.

It is important to recognize that our analysis can incorporate a role for options in realigning risk-related incentive problems by convexifying payoffs to risk-averse managers, recognizing that risk considerations can distort both the decision criterion (see Jenter, 2002). One role that risk considerations could play in an expanded model is to provide a role a positive salary. With risk-neutral agents, our theory currently indicates a zero salary is optimal, but a positive salary as part of the overall optimal compensation package could emerge if agents' utility functions were strictly concave over low levels of income. Further, it is likely that at lower-management levels, risk considerations are of increased importance and should therefore be incorporated into an analysis of more broadly based stock-option compensation.

[30] While we report results that characterize the position- or title-bases ranking as a continuous variable (i.e., rank from −3 to −1), point estimates on separate categorical variables suggest that the proportion of equity awarded as stock options decreases monotonically in position, with statistically significant differences between highest- and lowest-ranking executives.

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