Work hard, not smart: Stock options as compensation

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This paper examines the optimal compensation package for executives, in particular the optimal mix of stock options and stock grants, for an agent deciding whether to adopt or reject a plan of uncertain value. The compensation structure in such a setting affects not only an executive's efforts to improve the precision of signals regarding the true value of proposed plans but also the choice of a reservation signal that determines the likelihood a proposed plan is adopted. While stock options can bias an executive's decision criteria away from first-best, we show that the leverage they provide to motivate an executive to undertake more extensive plan evaluation makes options the preferred form of equity compensation if the exercise price is freely chosen. However, there is a role for restricted stock in realigning the interests of the executive with shareholders if the firm is constrained in the choice of the exercise price, which we argue may sometimes be the case. Using extensive data on top-executive compensation, we report evidence on this tradeoff that is consistent with the theoretical predictions. We also find that the extent of option compensation among top executives at a firm is associated with an increase in the likelihood of extreme returns in subsequent periods.

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Abstract: This paper examines the optimal compensation package for executives, in particular the optimal mix of stock options and stock grants, for an agent deciding whether to adopt or reject a plan of uncertain value. The compensation structure in such a setting affects not only an executive's efforts to improve the precision of signals regarding the true value of proposed plans but also the choice of a reservation signal that determines the likelihood a proposed plan is adopted. While stock options can bias an executive's decision criteria away from first-best, we show that the leverage they provide to motivate an executive to undertake more extensive plan evaluation makes options the preferred form of equity compensation if the exercise price is freely chosen. However, there is a role for restricted stock in realigning the interests of the executive with shareholders if the firm is constrained in the choice of the exercise price, which we argue may sometimes be the case. Using extensive data on top-executive compensation, we report evidence on this tradeoff that is consistent with the theoretical predictions. We also find that the extent of option compensation among top executives at a firm is associated with an increase in the likelihood of extreme returns in subsequent periods.

A central thesis of the extensive principal-agent literature is the incentive effect on an agent's effort that derives from linking compensation to a measure of the agent's output, albeit at the expense of exposing a risk-averse agent to uncertain compensation.[1] More recently, the literature has considered multiple dimensions to the actions taken by agents depending on the circumstances.[2] When agents are executives, expanding the characterization of the activities of the agent is particularly important. For instance, Murphy (1999) writes that "although the [executive's] 'action space' is typically defined as one-dimensional effort, it is widely acknowledged that the fundamental shareholder-manager agency problem is not getting the [executive] to work harder, but rather getting him to choose actions that increase rather than decrease shareholder value. [In part], increasing shareholder wealth involves investing in positive net present value plans" (p.28).

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[1] Garen (1994) is one of the first papers to develop and test predictions of the standard principal-agent model with respect to executive compensation.

[2] The classic paper introducing multiple activities of agents is Holmström and Milgrom (1991), where the additional activity can be actions such as quality control or maintenance of capital assets. Other examples include Milgrom (1988), where the additional activity involves actions to influence task assignments; Lazear (1989), where the additional activity involves the sabotage coworkers' contribution to output; Drago and Garvey (1998), where the additional activity is helping others perform their tasks; and Wulf (1999, 2001), where additional activities are influence actions and the distortion of subjective information about investment opportunities.

The paper is organized as follows. Section 1 introduces a model in which a risk-neutral executive must choose to adopt or reject a proposed plan of uncertain outcome based on an imperfect signal of the plan's value. The executive also chooses a level of effort to invest in the process of evaluation – an investment that affects the informativeness of the signal of the plan's value.[3] The purpose of the model is to evaluate the use in executive compensation packages of two forms of equity-based compensation: restricted stock grants and stock options, as well as to explore the potential link between the use of stock options and the performance of firms. In the model, option-based equity compensation moves effort toward first best, but distorts executive decision making away from first best. Thus, in contrast to the common adage for managers to "work smart, not hard," we find that stock options encourage a "work hard, not smart" approach relative to restricted stock.

To illustrate the potential effect of stock grants versus stock options on executives' actions, Section 2 considers how the substitution between stock grants and stock options influences the behavior of executives and shows that if the firm is unconstrained in its choice of the exercise price on options awarded to an executive, the optimal equity compensation package consists only of options. In other words, the optimal exercise price allows the principal to limit the decision-distortion consequences associated with options while taking advantage of the capacity of options to encourage effort through leverage.

There are two important features of our theory. First, unlike Hall and Murphy (2000), risk aversion on the part of executives is not necessary for a finite optimal exercise value in our model.[4] This result arises from an expansion of the executive's problem to a project-selection setting in which options can distort executive decision making, and increasingly so as the exercise price

[3] This view follows Barron and Waddell (2003) Other papers that consider a project-selection decision include: Lambert (1986), Holmström and Ricart-i-Costa (1986), Campbell, Chan and Marino (1989), Smith and Watts (1992), Hirshliefer and Suh (1992), and Bizjak, Brickley and Coles (1993).

[4] Hall and Murphy (2000) 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."

increases.[5] A second important feature of our analysis is that the model yields a "knife-edge" result whereby optimal equity-based compensation package switches from almost all restricted stock to all stock options if the exercise price falls below a critical level. As all-options equity awards are common in practice, identifying conditions under which all-option equity awards are optimal is an appealing aspect of the theory.[6]

Section 3 provides a systematic examination of the composition of equity-based compensation among top executives. Although the use of options rather than restricted stock is widespread, there remain instances when the compensation packages of top executives include restricted stock. To explain the use of restricted stock over options in our setting, we explore the implications of restrictions on the setting of the exercise value. We start by noting that our evidence for top-executive stock-option compensation confirms Hall and Murphy's (2000) observation that the "exercise price is nearly always set equal to the current stock price" (p. 209). We explore reasons why firms may follow a simple rule of thumb in setting the exercise price equal to the grant-date market price (i.e., "at the money") and the consequences of such a rule. Simulations are used to show that the firm will introduce restricted stock into the executive's compensation if such a rule of thumb results in the exercise price being too high. In such cases, the restricted stock component of equity compensation acts to increase the executive's concern for accepting bad projects and moves the agent's decision rule toward first-best, although typically at the expense of less effort.

Section 4 develops hypotheses based on the simulations presented in Section 3 and reports the results of empirical tests of these hypotheses using an extensive collection of data recorded directly from the proxy statements of over 1,400 publicly traded US companies over 1992-2000. The

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[5] Note also that in our setting, options can be the preferred means of compensation. This contrasts with Jenter (2001), who finds options to be an inferior means of inducing managerial effort incentives. Jenter's result relies on a risk-averse manager's undervaluation of option awards relative to the market and a downplaying of the leverage role for options in inducing effort.

[6] Our focus is on stock option compensation for top executives. For discussions of various rationales supporting a more broad-based use of options, see Hall and Murphy (2003) and Oyer and Schaefer (2003). Hall and Murphy focus on the misperception of boards and managers regarding the cost of options, while Oyer and Schaefer focus on the roles of retention and sorting.

analysis identifies variables that can increase the likelihood an at-the-money exercise price is higher than optimal for the alignment of incentives, and thus should lead to a reduced use of options as a proportion of an executive's equity-based compensation. Consistent with the predictions of the model, we find a systematic tendency to use stock options over restricted stock in research-intensive environments, in smaller firms, and in firms that do not have a policy of paying dividends. Interestingly, we also find evidence that, for both pooled and fixed-effect specifications, higher-ranking executives are *less* likely to have a given dollar of equity compensation awarded in the form of stock options. This provides strong support for the idea that as one moves up the ranks of top executives, the distortion effects of stock options become more important, and thus options play a less important role in equity compensation.

Section 5 explores the link between the use of option-based compensation among the top executives of a firm and the subsequent pattern of firm returns. Our analysis indicates that executives are more likely to choose an uncertain plan that is either better or worse than the status quo if options are substituted for restricted stock. This suggests that, other things equal, returns should be more extreme when compensation is weighted toward options. The empirical analysis finds support for this prediction. Namely, a firm's subsequent three-year return is more likely to be extreme (in the top or bottom 20 percent of returns) if the option proportion of total compensation among top executives at the firm is higher. Section 6 contains concluding remarks and potential extensions.

It is important to note at the outset that our focus is on stock option versus stock grant compensation in lieu of a more general analysis of the optimal compensation package.[7] The rationale for doing so is threefold: the observed importance of equity-based compensation in the

[7] See Barron and Waddell (2003) for further discussion of such issues as well as evidence on the use of incentive-based pay in general.

compensation packages of top executives;[8] a desire to distinguish the different incentive effects of these two types of equity-based awards that are overlooked in many models of executive compensation;[9] and the perception in the popular press that the main purpose of options is to generate artificially high profits as such compensation need not be expensed.[10] With regard to this final point, the model introduces a positive feature of options in encouraging effort that can result in the extensive use of options in spite of their potential to enrich executives as well as to induce executives to take unwarranted risks from the perspective of shareholders.

1. A model of plan selection

Consider n executive positions at a firm ordered according to rank, $r = 1, \ldots, n$, with the most-senior position having a rank of $r = 1$. At this point, it is sufficient for one to regard more senior positions as positions in which more important decisions are made; below we make specific what we mean by more important decisions.

1.1. Plan characteristics and executive decision variables

Following Barron and Waddell (2003), and in the spirit of Lambert (1986), the role of the executive in each of these n positions is to determine whether to accept or reject a single proposed plan that is one of only two types (good or bad) with expected future gross values, V_r^G and V_r^B, respectively. The values for all plans are bounded on the left by zero and that $V_r^B < V_r^o < V_r^G$, so that a good plan has an expected value above the status quo, V_r^o, while the bad plan's expected

[8] See, for instance, Yermack (1995), Hall and Liebman (1998), Core and Guay (1999), Murphy (1999), and Barron and Waddell (2003).
[9] For examples of analysis that does not distinguish types of equity-based compensation, see Barron and Waddell (2003) and the literature cited in this paper.
[10] For example, consider the following quote taken from the article "What W. Didn't Learn From Enron" by John B. Judis that appeared in the May 6, 2002, issue of *The New Republic*. "What is problematic (regarding stock options) is the way companies count them on their financial records and tax returns. As the law now stands, companies don't have to deduct stock options from the profit totals on their financial statements even though, like wages, the options are a form of compensation. This omission played a key role in creating the wildly inflated profits and consequent euphoria that fueled the '90s stock market bubble."

value is below the status quo.[11] The exogenous and known probability that the plan to be evaluated by executive *r* is good is denoted by α_r.

Unlike Barron and Waddell (2003), we introduce non-degenerate distributions h_r^G and h_r^B for the realized values of good and bad plans, respectively, with standard errors σ_r^G and σ_r^B. As will become apparent, given our focus on stock options, this modification is necessary to eliminate a bias towards the use of options that otherwise could exist for positive exercise prices; without this modification, the distorting effect of options on decision making that we identify below would not exist for a range of positive exercise prices. Let h_r^o and σ_r^o represent the density function and standard error of the status quo "plan."

If the objective is to maximize the expected future value of the plan, the stochastic nature of the signal generating process leads the executive to err in plan selection in one of two ways. Adopting the terminology of Sah and Stiglitz (1988), the rejection of a good plan by the executive is a Type I error and the adoption of a bad plan is a Type II error. In evaluating a plan, assume that an executive in a position of rank *r* who incurs unobservable effort e_r receives an imperfect signal *s* of the plan's underlying value to the firm. If the plan is good, the signal is drawn from a normal distribution with cumulative density function $F_G(e_r, s)$ with mean μ_G and precision $P_r(e_r, \upsilon)$, where $\partial P_r / \partial e_r > 0$, $\partial^2 P_r / \partial e_r^2 \le 0$ and υ is a parameter affecting the precision of the signal for a given level of effort.[12] If the plan is bad, the signal is drawn from normal distribution $F_B(e_r, s)$ with mean $\mu_B < \mu_G$ and precision $P_r(e_r, \upsilon)$.

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[11] For simplicity, we assume that the principal ranks plans solely on the basis of their expected value. This need not be the case. For instance, the simple capital asset pricing model suggests that risk-averse shareholders value stocks in their portfolio based on considerations beyond their expected return.

[12] For discussion purposes we talk of signal precision and not signal variance; precision is simply the reciprocal of the variance of the signal.

The executive decides to accept or reject a project based on the executive's choice of reservation signal $\hat{s}_r$. If the signal obtained for the proposed plan is above the chosen reservation signal, the executive adopts the plan. If the signal obtained is less than $\hat{s}_r$, the executive rejects the plan in favor of the status quo.[13] For a given evaluation effort e_r and reservation signal $\hat{s}_r$, the executive therefore rejects a proposed plan that is good with probability $F_G(e_r, \hat{s}_r)$. Likewise, the executive adopts a proposed plan that is bad with probability $1 - F_B(e_r, \hat{s}_r)$. Thus, an increase in $\hat{s}_r$ increases the likelihood of Type I error but reduces the likelihood of Type II error.

1.2. The first-best solution

The expected future gross value to the principal of the plan-selection decision of an executive in position of rank *r* is given by:

$$(1) \qquad E[V_r\,(e_r, \hat{s}_r)] = V_r^* - F_G(e_r, \hat{s}_r)k_r^I - (1 - F_B(e_r, \hat{s}_r))k_r^{II} \quad ,$$

where $k_r^I = \alpha_r L_r^I$ and $k_r^{II} = (1-\alpha_r)L_r^{II}$ denote the expected losses from Type I and Type II errors for shareholders, with $L_r^I = V_r^G - V_r^o$ and $L_r^{II} = V_r^o - V_r^B$. According to Eq. (1), the best possible outcome ($V_r^* = \alpha_r V_r^G + (1-\alpha_r)V_r^o$) is reduced by losses associated with Type I errors (L_r^I) and Type II errors (L_r^{II}).[14]

Where returns are additively separable across executives and effort costs are quadratic ($c(e_r) = e_r^2/2$), the first-best e_r and $\hat{s}_r$ that maximize shareholder return satisfy the problem:

$$(2) \qquad \max_{e_r, \hat{s}_r} \quad \rho \mathrm{E}[V_r\,(e_r, \hat{s}_r)] - e_r^2/2 \quad ,$$

where the discount factor $\rho \in [0,1]$ converts the gross future value into current values. The first-

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[13] Note that we keep matters simple by assuming the executive evaluates a single proposed plan. One could instead consider the executive as engaged in sampling plans from a pool of potential plans. In this case, one would reinterpret the status quo as the value to continued search (i.e., drawing another proposed plan to evaluate).

[14] In the analysis to follow, we assume that the costs of these errors are sufficiently large that it is not optimal for the principal to adopt the simple rule of either always rejecting or always accepting proposals.

best reservation signal, $\hat{s}_r^*$, is given by:

$$\hat{s}_r^* = \frac{-\ln\left(\Phi_r\right)}{P_r(e_r)\ (\mu_G - \mu_B)} + \frac{\mu_G + \mu_B}{2} \quad , \tag{3}$$

where

$$\Phi_r = k_r^I / k_r^{II} \tag{4}$$

denotes the ratio of expected losses from Type I and Type II errors made by an executive in the position of rank *r*.[15]

Given the optimal reservation signal, $\hat{s}_r^*$, the first-order condition that defines the first-best evaluation effort, e_r^*, is:

$$e_r^* = \rho\left(-\frac{\partial F_G(e_r^*, \hat{s}_r^*)}{\partial e_r} k_r^I - \frac{\partial (1 - F_B(e_r^*, \hat{s}_r^*))}{\partial e_r} k_r^{II} \right) \quad . \tag{5}$$

The optimal evaluation effort from the shareholders' perspective equates the marginal cost of effort with the marginal benefit arising from the effect of effort on reducing the expected costs of making Type I and Type II errors given $\hat{s}_r^*$.

2. A Stylized Executive Compensation Package

In order to understand the advantages and disadvantages of stock grants versus stock options, we contrast the first-best decision-making choices above with those of a risk-neutral executive when compensation takes the form of options and restricted stock. In doing so, we demonstrate that the granting of stock options in place of restricted stock provides leverage to the firm in inducing executive effort, but comes at a potential cost of distorting the agent's decision criteria toward too-frequent Type II errors (adopting a bad plan).

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[15] Note that if symmetry exists in the expected gain and loss from plan selection, such that $k_r^I \equiv \alpha_r(V_r^G - V_r^o) = (1-\alpha_r)(V_r^o - V_r^B) \equiv k_r^{II}$ and $\Phi_r = 1$, then the decision criterion is independent of the specific level of evaluation effort.

Restricted stock grants award a fixed number of equity shares to the executive with restrictions on the reselling of the asset. Such contracts specify a time schedule for relaxation of such marketability-restrictions, with the typical vesting period being less than 50 months (Murphy, 1999). Stock options, on the other hand, give the executive the right to buy shares of firm stock at a pre-specified exercise price over a pre-specified term, often vested over time. For example, one third of the options specified in the grant might become exercisable in each of the three years following the grant. Options that are awarded to executives are non-tradable and are typically forfeited if the executive leaves the firm before vesting.

While many differences can be identified between stock grants and options, for our purposes the fundamental difference between the two types of equity awards is their implied exercise prices: zero for stocks and strictly positive for options. To simplify our analysis, we focus on this key distinction by assuming away all other differences.[16] For tractability, we also assume that the time period to vesting for stock grants and options equals the time period until the realization of the plan's value. To maintain a simple characterization of the value at the time of vesting for option grants, we also assume that options are exercised when vested. Given these simplifying assumptions, the current value of executive *r*'s compensation package, a value that depends on the discounted future realized value of the firm, *V*, takes the form:

$$(6) \qquad C_r = \begin{cases} \delta_r + \rho(\beta_r^R V + \beta_r^O (V - V^E)) & if \;\; 0 < V^E \le V \\ \delta_r + \rho(\beta_r^R V) & if \;\; V < V^E \end{cases} .$$

In Eq. (6), δ_r is the salary component of the executive's remuneration. The parameters β_r^R and β_r^O can be interpreted as the proportion of the firm's value V and the proportion of the firm's value in excess of the "exercise value" V^E that the executive will acquire through stock holdings

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[16] For a discussion of the differences in vesting schedules between stock grants and option grants, see Kole (1997) and Murphy (1999).

and stock options, respectively. We adopt a common discount factor of $\rho < 1$. Eq. (6) illustrates that for stock options, unlike restricted stock, the executive realizes increased wealth only if the firm's future value exceeds the exercise value, V^E. While we cast the option as having an exercise "value," this value is analogous to the exercise price on the option grant and is set prior to the executive choosing evaluation effort and the criterion for adopting or rejecting the proposed plan.

Before defining the agent's optimization problem, it is helpful to characterize the expected compensation that is implied by (6). To simplify the presentation to follow, we assume a single executive (n = 1).[17] Assume the realized value for the decision made by the executive has common lower and upper bounds of zero and $\bar{V}$, respectively. Then, the expected future value of the firm from (1) is given by:

$$\text{(7)} \qquad \mathrm{E}[V] = \alpha_r \int_0^{\bar{V}} x h_r^G(x)\,dx + (1-\alpha_r)\int_0^{\bar{V}} x h_r^o(x)\,dx - F_G k_r^I - (1-F_B)k_r^{II} \quad ,$$

where the expected losses to firm value from rejecting a good proposal or accepting a bad proposal are, respectively:

$$\text{(8)} \qquad k^I = \alpha_r \int_0^{\bar{V}} x\,(h_r^G(x) - h_r^o(x))\,dx$$

and

$$\text{(9)} \qquad k_r^{II} = (1-\alpha_r)\int_0^{\bar{V}} x\,(h_r^o(x) - h_r^B(x))\,dx \quad .$$

When equity is awarded to the executive in the form of restricted stock, it is this characterization of firm value that is of ultimate interest to the executive.

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[17] A formal statement of the more general problem when $n > 1$ is available from the authors upon request. Note that the insights obtained from the single executive case carry over to the case of more than one executive given our prior assumption that firm value is simply the sum of the value of individual executive projects. One area for future analysis is to consider the more general case when actions by one executive can affect the project values faced by others.

In contrast, the option holder is interested in the expected value of the firm as it relates to an exogenous exercise value, V^E.[18] Recall that unless options are in the money when exercisable ($V^E < V$), the executive realizes no increase in income from having the option to purchase firm stock. That is,

$$\begin{aligned} \mathrm{E}[V^O] &= E[\,V - V^E \,|\, V \geq V^E\,]\Pr(V \geq V^E) \\ &= \alpha_r \int_{V^E}^{\bar{V}} (x - V^E) h_r^G(x)dx + (1-\alpha_r)\int_{V^E}^{\bar{V}} (x - V^E) h_r^o(x)dx - F_G \phi_r^I k_r^I - (1-F_B)\phi_r^{II} k_r^{II} \end{aligned} \quad (10)$$

To make the comparison between equity and options more transparent, in (10) we express the losses from Type I and Type II errors for an option holder as fractions of the losses from such errors for one who holds stock grants, defined earlier as L_r^I and L_r^{II}, respectively. In particular, the loss from a Type I error for an option holder is denoted by $\phi_r^I k_r^I$ and the loss from a Type II error for an option holder is denoted by $\phi_r^{II} k_r^{II}$, such that:

$$\phi^I k^I = \alpha \int_{V^E}^{\bar{V}} (x - V^E)(h^G(x) - h^o(x))dx \quad (11)$$

and

$$\phi^{II} k^{II} = (1-\alpha\ ) \int_{V^E}^{\bar{V}} (x - V^E)(h^o(x) - h^B(x))\,dx \quad . \quad (12)$$

Recall that the non-zero exercise value is the single difference in our model between a stock grant and an option grant, such that $\lim_{V^E \to 0} \phi_r^I = 1$, $\lim_{V^E \to 0} \phi_r^{II} = 1$ and $\lim_{V^E \to 0} \mathrm{E}(V^O) = \mathrm{E}(V)$.

[18] Most firms almost universally set the exercise price equal to the current stock price (Murphy, 1985; Smith and Zimmerman, 1976). For a discussion of optimal strike prices see Hall and Murphy (2000).

2.1 Effort and plan selection of a risk-neutral agent

When compensation can include both firm stock and stock options, the problem for a risk-neutral agent is to choose effort and reservation signal to maximize expected compensation as given by (6). That is, the executive's problem is:

$$\max_{e_r, \hat{s}_r} \quad \delta_r + \rho(\beta_r^R \mathrm{E}[V] + \beta_r^O \mathrm{E}[V^O]) - c(e_r) \quad , \tag{13}$$

where (7) and (10) define $\mathrm{E}(V)$ and $\mathrm{E}(V^O)$, respectively. The first-order conditions for the executive's reservation signal and effort are:

$$\hat{s}_r^{**} = \frac{-\ln\left(\Phi_r^E\right)}{P(e_r^*)\,(\mu_G - \mu_B)} + \frac{\mu_G + \mu_B}{2} \tag{14}$$

and

$$e_r^{**} = -\rho\left(\frac{\partial F_G(e_r^{**}, \hat{s}_r^{**})}{\partial e_r}\right)(\beta_r^R + \phi_r^I \beta_r^O)k_r^I + \rho\left(\frac{\partial F_B(e_r^{**}, \hat{s}_r^{**})}{\partial e_r}\right)(\beta_r^R + \phi_r^{II} \beta_r^O)k_r^{II} \quad , \tag{15}$$

where the ratio of expected losses from Type I and Type II errors for the executive is given by:

$$\Phi_r^E = \frac{(\beta_r^R + \phi_r^I \beta_r^O)k_r^I}{(\beta_r^R + \phi_r^{II} \beta_r^O)k_r^{II}} \quad . \tag{16}$$

Note that the relative importance of Type I and Type II errors is determined by β_r^R and β_r^O (the weights for these two types of compensation) and by ϕ_r^I and ϕ_r^{II} (the ratio of losses from Type I error for option recipients versus stock recipients and the ratio of losses from Type II error for option versus stock recipients, respectively). As in the first-best solution above, if symmetry exists in the expected gain and loss from plan selection, then the decision criterion is independent of the specific level of evaluation effort.

2.2 The Principal's problem

Even for the single-agent case, characterizing the optimal compensation package that can include both options and stock 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 optimal exercise value. In particular, the principal's problem is:

$$\max_{\delta_r, \beta_r^R, \beta_r^O, V^E, e_r, \hat{s}_r} \rho \mathrm{E}[V] - E[C_r] \quad , \tag{17}$$

subject to the agent's optimal choices of reservation signal and effort (the incentive compatibility constraints (14) and (15)), the agent's rationality constraint ($E(C_r) - e_r^2 / 2 = u_r$), and non-negativity constraints on δ_r, β_r^R, β_r^O and V^E.

Ultimately, we resort to simulations to provide insight into the nature of the solution. However, we start by focusing on two special cases in order to highlight the potential positive role options can play in encouraging hard work (Section 2.3) and the negative role of options in distorting executive decision making (Section 2.4). Section 2.5 then illustrates the optimal choice of the exercise value, noting the fact that in our setup, if a positive exercise value is optimal and the principal is unconstrained in this choice, only options will be used in the compensation package.

2.3 Options encourage hard work

Recall that the single feature that distinguishes stock options from restricted stock grants in our model is the exercise value. Increasing the exercise value can encourage agents to "work hard." To isolate this feature of option grants, assume that very low realizations of firm value (i.e. firm values approaching zero) are unlikely regardless of the executive's decision. In this case, as shown in Supplement A, for any given $\beta_r^O > 0$, an increase in the exercise value from zero provides a "leverage" gain. This leveraging arises as an increase in V^E lowers the agent's expected value of a given number of options and therefore allows more options to be included in the contract subject to the agent's individual rationality constraint. An increase in the number of options induces the agent to choose an effort level closer to first-best as the marginal return to effort is higher.

As Supplement A demonstrates, we can generalize this result if we assume symmetry in the underlying costs to the Principal of Type I and Type II errors. Under such an assumption, if the difference in the likelihood of bankruptcy (i.e. zero firm value) from a bad project and the likelihood of bankruptcy from a good plan is sufficiently small, we can again establish a strictly positive effect on effort from the leverage that is coincident with increasing the exercise value from zero.

2.4 Options distort decisions

Our twofold characterization of the executive's problem reveals that the benefit from substituting restricted stock for options, the encouragement of effort through leveraging, is tempered by a negative effect on the chosen reservation signal. This negative effect arises because options reduce the decision-maker's costs of adopting the proposed plan. Recall that the option recipient realizes an increase in income only when the realized value of the firm's stock exceeds the pre-determined exercise value, and then only receives the difference between the realized stock value and the exercise value. Thus, from the perspective of the executive, an increase in the exercise value from zero initially replaces what would be relatively low-value outcomes with zero-value outcomes. However, key to the distortion is that this replacement is asymmetric with respect to plan type. For any exercise value V^E, there is larger mass below V^E under the distribution of outcomes from the adoption of a bad plan then there is below V^E under the distribution of outcomes from the status quo and, in turn, from the adoption of a good plan. This asymmetry leads the agent to choose a reservation signal that is strictly biased downward if options are included in the compensation package.

This bias can be significant, and acts to limit the magnitude of the optimal exercise value on options awarded to the agent. To illustrate the downside to the use of options on the chosen reservation signal, assume for the moment that the agent's effort choice is first best. It follows from

(3), (4), (14), and (16), that the first best reservation signal is chosen if the executive faces the same ratio of losses as the principal. That is, if $\Phi_r = \Phi_r^E$, or

(18) $$\frac{\beta_r^R + \phi_r^I \beta_r^O}{\beta_r^R + \phi_r^{II} \beta_r^O} = 1 \quad .$$

For a positive V^E, $\phi_r^I > \phi_r^{II}$ and Eq. (18) does not hold; for an option recipient (i.e. for $\beta_r^O > 0$), a Type II error (approving a bad plan) is now relatively less important than it is for the principal or stock recipient.[19] Comparing (3) and (14), this asymmetry in losses across types of compensation means that $\hat{s}_r^{**} < \hat{s}_r^*$. In other words, with options the expected cost of a Type II error falls relative to that of a Type I error, motivating the agent to choose a reservation signal that increases the likelihood of making a Type II error.

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

The preceding two sections outline the tradeoff that is coincident with an increase in the exercise value of stock options. Higher exercise values tend to encourage evaluation effort but at the expense of a lower standard for plan adoption being chosen by the agent. Figure 1 reveals the tradeoffs implied by an increasing exercise value. The panels depicted in Figure 1 are obtained from simulations of the model assuming the principal optimally chooses the mix of stock options and stock at each exercise value.[20]

In each of the five panels in Figure 1, the triangle on the axis indicates the optimal exercise value. This exercise value maximizes the value of the firm net of compensation, as illustrated by Panel E. Panel A documents the leverage effect of options, showing the increase in the agent's level of effort that accompanies an increase in the exercise value. For low levels of V^E, this leverage effect leads to an optimal compensation package that consists of only stock options, as

[19] Supplement A provides the specific assumptions that support this statement.
[20] Supplement B identifies the underlying parameter values used to obtain the simulated results presented in Figure 1. The results discussed are robust to parameter changes.

illustrated in Panel D. However, as Panel B indicates, an increasing exercise value introduces distortions in the reservation signal away from first-best levels ($\hat{s}_r = 0$), and eventually leads to a significant bias toward Type II error (accepting a bad project) as shown in Panel C. At that point, the distortion induced by options more than offsets the gain from effort enhancement, and the use of options is abruptly discontinued, as illustrated in Panel D. Figure 2 illustrates this "knife-edge" characteristic of the optimal compensation package, showing how a small increase in the exercise value can result in a jump in the optimal compensation package from one that is options to one that is predominately stock grants.

3. Evidence on compensation packages

Collectively, the panels in Figure 1 illustrate an important feature of the principal's problem. 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. This is formally demonstrated in Supplement A, where we show that at the optimal level of V^E, the salary component is zero ($\delta_r = 0$) and the level of restricted stock grants is zero ($\beta_r^R = 0$), such that all compensation is in the form of options.

To determine to what extent this holds for actual compensation packages, we examine 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 2000.[21] Limiting our attention to executives who receive equity compensation yields a sample of over 55,000 executive-year observations, reflecting the compensation of the top 5 executives at approximately 1,500 firms each year.

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[21] 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) provides further details on the identification of the top five executives at each firm. Note that since our analysis focuses on option compensation, the sample differs from that in Barron and Waddell as 4,175 observations that have missing information regarding the value of options are dropped.

3.1 The predominate use of options

Table 1 indicates the breakdown of compensation by year, first with respect to the proportion of executives with equity-based compensation and then, for those with equity-based compensation, with respect to the extent to which options are used. Note that over the 9-year period, there was an increased use of equity-based compensation, with over 85 percent of top executives in 2000 receiving some compensation that is equity based. Table 1 reveals that each year over 74 percent of such equity-based compensation packages rely solely on options. This provides some support for the clear advantage of options predicted by the theory when the exercise price is optimally chosen.

However, Table 1 also indicates instances when restricted stock is used, both in combination with options and by itself. Simulations of our model when different exercise values are specified highlight a reason why the granting of restricted stock may supplement the granting of options. In particular, if the exercise value of an option award is set above what would be optimal, some compensation in the form of restricted stock can be optimal.

3.2 The practice of setting the exercise value equal to market value

In the sample of executives in the *ExecuComp* dataset between 1992 and 2000 there are 81,118 individual option awards made, with over 95 percent of these awards made at the money.[22] In the context of our model, this suggests a near-universal rule for setting the exercise value, V^E, equal to the grant-date market value of the firm's stock. If such a "rule of thumb" were to exist, then from an incentive standpoint alone, the exercise price associated with some contracted options could be higher than optimal. At the very least, it is unlikely to be the case that the incentive-optimal exercise prices are so commonly set equal to firms' stock prices, both within and across firms.

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[22] This is consistent with the findings reported in Hall and Murphy (2000), who 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). Note that our approach assumes a risk-neutral agent, and so is not directly comparable to the analysis of Hall and Murphy.

But, why would the exercise price of options not be set optimally from the perspective of the recipient's decision-making incentives? Consider two potential reasons. The first reflects the growing evidence that individuals, in our case executives, 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. The result is to add a second component into 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, to reduce compensation costs, the principal can now find it less costly to set the exercise price equal to the market price even if doing so reduces the gross value of the project selection process. Note that this rationale for treating executives the same with respect to the setting of the exercise price applies not only for within-firm comparisons but also for across-firm comparisons.

A second potential reason for an exercise price set differently from that predicted by our simply theory, at least with respect to the awarding of options in the money, is that there are potential accounting disadvantages to deviating from this rule-of-thumb that are not explicitly modeled.[23] 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 the next section, we take as given the particular rationale for an at-the-money constraint, be it fairness, accounting issues, or some other reason. We then address how such a constraint influences optimal equity-based compensation packages.

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[23] However, 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. Note that we have also abstracted from the issues of the optimal timing by which the executive exercises options, something to be considered in subsequent research.

3.3. The optimal compensation package with a binding constraint on the exercise value

In our simulation of a firm with a single executive, we define the current market value of the firm, V^C, as the principal's present value of the firm, net of compensation costs, given first-best effort and signal cut-off. We discount the expected firm value to reflect the time that elapses before the value from chosen project is realized, such that:

$$V^C = \rho E[V(e_r^*, \hat{s}_r^*)] - E[C_r(e_r^*)] \quad . \tag{19}$$

For our benchmark case, we choose initial parameter values such that the optimal exercise value equals the first-best current market value of the firm as defined by (19). Thus, our benchmark simulation can be interpreted as one for which it is optimal for the principal to follow the simple rule of thumb of setting the exercise value equal to the grant-date market value of the firm.[24] We then consider the effect of changes in parameter values on the optimal agent's compensation package assuming the principal maintains the exercise value at the money. We explore, in particular, parameter changes that result in the exercise value being set too high, leading to a mix of stocks and options in the optimal compensation package. The three parameter changes we consider relate to the characteristics of the proposed plan, the quality of the signal that the executive receives regarding the plan's type, and the characteristics of the "default plan" that we refer to as the status quo.

First, consider an increase in V_r^G and a decrease in V_r^B that are equal in size. The result is an increase in the difference between the expected values of good and bad proposed projects, V_r^G and V_r^B, respectively. This greater difference increases the importance of decisions being made in that the individual decision maker has greater influence on the future value of the firm when this difference is larger. Holding V_r^o constant, it is clear that these changes increase to the same degree

[24] Supplement B provides details regarding the benchmark parameters.

the underlying costs to the stock holder of a Type I error ($V_r^G - V_r^o$) and a Type II error ($V_r^o - V_r^B$). However, for the option holder the increases in costs of errors are asymmetric, as the strictly positive exercise value results in a relatively larger increase in the cost of Type I error (rejecting a good project). Ceteris paribus, this leads the option holder to lower the chosen reservation signal. In response, the optimal exercise value falls 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 to setting a higher exercise value.

If, however, we consider the case where the principal is constrained to set the exercise value at the money (i.e. $V^E = V^C$), then our theory suggests that the principal may find a substitution of restricted stock in place of stock options to be optimal, with a resulting decrease in the proportion of equity-based compensation that is options. Our simulations bear this out. When decisions carry the potential for greater upside and downside consequences, stock options are a potentially less-favorable method of linking executive wealth to firm value, and we expect to see more use of restricted stock.

Now consider an increase in the informativeness of the signal of plan type as reflected by a decrease in the parameter υ, a parameter directly related to the variance in the signal, and thus inversely related to the precision of the signal, P_r. Assume such an increase in the quality of the signal for a given evaluation effort also reduces the marginal impact of increased effort on signal precision.[25] With such an increase in the informativeness of the signal, the gain to the use of options to encourage effort is reduced, and thus the optimal exercise value falls. If the principal is constrained to set the exercise value at the money ($V^E = V^C$), the firm can find it optimal to

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[25] That is, we assume $\partial P_r / \partial \upsilon < 0$ and $\partial P_r^2 / \partial e_r \partial \upsilon > 0$. In our simulations, we adopt the following specific form for the signal precision function: $P_r = 1/(\gamma + (\upsilon/(1+\lambda)e_r))$. Naturally, given this form, our discussion in the text regarding the effect of a decrease in υ also holds for an increase in the parameter λ.

accommodate such an increase in signal precision by substituting restricted stock in place of stock options. Our simulations again bear this out.

Finally, consider the effect of a mean-preserving reduction in the spread of the density function of the status quo outcome, h_r^o. For an option holder, such a decrease in the variance of the status quo enhances the attractiveness of trying out the new, more uncertain project. To offset this tendency, there would be a decrease in the optimal exercise value relative to the firm's market value. If the principal is constrained in the choice of exercise value, not being able to lower V^E in response to such a change, then the principal may find the substitution of stock grants for options optimal to temper the increased attractiveness of the uncertain project over the status quo for the option holder. Our simulations bear this out. A decrease in the variability of the status-quo firm value with a fixed exercise value can reduce the optimal proportion of equity-based compensation that is stock options.

4. Hypotheses and Tests Regarding the Use of Restricted Stock and Stock Options

The prior section considered parameter changes that make it more likely a simple rule of thumb that sets exercise values equal to market values yields higher-than-optimal exercise values. In this section, we identify proxies for such parameter changes that lead to testable hypotheses with respect to the use of restricted stock grants in place of options.

4.1. Hypotheses regarding the use of options

The first comparative static result above suggests that a relationship exists between the use of stock options and the importance of the decision as measured in the theory by the difference between the value of a good and a bad project. We posit that executives who are more senior within their respective firms make more important decisions. In such cases, stock options, by downplaying very bad outcomes, make the executive too willing to try new, uncertain projects. If the firm is constrained in terms of reducing the exercise price below an at-the-money value, the optimal proportion of proportion of equity-based compensation that is awarded in the form of stock options falls. Thus we hypothesize the following:

> **Hypothesis 1:** Executives who are relatively more important within their respective firms are less likely to have a given dollar of equity-compensation awarded in the form stock options.

We use the measure of the relative importance of an executive within the firm introduced in Barron and Waddell (2003), namely the log of the ratio of the executive's total compensation to the highest total compensation at the executive's firm in the same year. In the vast majority of cases, the highest compensation in a given year is that of the firm's CEO.

In the same spirit as Hypothesis 1, we also contend that executives at larger firms are likely to face larger consequences to adopting new projects. Specifically, we maintain that executives employed at larger firms in our sample likely make more important decisions in terms of their potential absolute influence on firm value than do executives at small firms in the sample. Sharing, then, the same motivation as Hypothesis 1, we have the following:

> **Hypothesis 2:** Executives at larger firms are less likely to have a given dollar of equity-compensation awarded in the form stock options.

We adopt as our empirical measure of firm size the logarithm of the book value of the firm's assets.

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 can be interpreted as both increasing the variance of the signal on project type for a given evaluation effort by the executive and raising the marginal gain from increased evaluation effort in terms of reducing signal variance. Our simulation results suggest that in such a case, the advantage of options in inducing increased evaluation effort by executives is enhanced.

The Statement of Financial Accounting Standard No. 2 classification of research and development expenditures suggests that the magnitude of R&D expenditures can serve to indicate the extent executive decisions involve new product development. Adopting the view that research-intensive environments are environments where efforts to improve the quality of the signal have a greater payoff, we have the following hypothesis:

> **Hypothesis 3:** Executives at firms with higher research and development expenditures are more likely to have a given dollar of equity-based compensation awarded in the form stock options.

Our empirical measure of research intensity is defined as the ratio of research and development expenditures to the firm's book value of asset.

Our analysis predicts a move away from options when the exercise price is constrained at too high a level. For a given future return to a project, the likelihood this constraint binds will be higher if potential future returns are paid out as dividends rather than retained, and thus reflected by an appreciation in the price of the firm’s stock. That is, 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. This increases the likelihood that the exercise price is set “too high.” We therefore hypothesize the following:[26]

> **Hypothesis 4:** If dividends have been paid in the past, then executives at such firms are less likely to have a given dollar of equity-based compensation awarded in the form of stock options.

The *ExecuComp* dataset reports the past-payment of dividends of the firm. We assume that if dividends have been paid in the past, this is associated with a perceived increased the likelihood of future dividend payments being made. Our measure for future dividend policy is thus a variable that equals one in the current period if the firm paid dividends in the preceding period, and zero otherwise.

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[26] Our view is that a reduced reliance in the past on dividends, by indicating a lower future propensity to pay dividends, helps 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 explain a reduced reliance on dividends in the future.

4.2. Tests of the hypotheses regarding the use of stock options

Our theory and the resulting four hypotheses to test have focused on the optimal use of options as a proportion of total equity-based compensation. Using the measured proportion as the 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. Further, as indicated in Table 1, the option-proportion of equity compensation is frequently at the upper or lower bounds. Recognizing these issues, we adopt the technique of Barron and Waddell (2003). That is, we rephrase our question concerning the proportion of equity awarded in a particular fashion to take the following form: "What determines the likelihood a given dollar of equity compensation is option-based?" thereby handling both the unit interval and the lumpiness of the proportional data.[27]

Table 2 summarizes the variables used in the analysis. In addition to the variables discussed above, we include a number of control variables. In particular, we include in our analysis the firm's prior-three-year total return to shareholders, including the monthly reinvestment of dividends. For approximately 10 percent of the observations in our sample, this variable is missing. For these cases, we set the return variable equal to the average across all firms. We then specify a dummy variable equal to one if the return is missing to identify systematic differences in option use for firms with missing values for the prior-three-year return variable.

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[27] Columns 1, 2 and 4 of Table 3 report the results of Probit models that accommodate this issue. For this estimation procedure, we create a binary variable equal to one for the original dataset and zero for a duplicate dataset. We then weight each "original" observation by the observed proportion of the executive's total equity compensation that is awarded as stock options and weight each "duplicate" observation with one minus this proportion. The fixed-effect results reported in Column (3) of Table 3 do not control for the boundedness of the dependent variable. Note, however, that the qualitative results reported in columns (1), (2) and (4) are robust to several treatments. Specifically, we get qualitatively similar results using simple proportions as the dependent variable, Logit-transformed proportions as the dependent variable or adopting a (simple or random-effects) Tobit estimation procedure where the boundedness is treated as though the data are both left- and right-censored. The results are also robust to an ordered Logit model where the observed proportions are transformed into mutually exclusive intervals and thereby into an ordinal approximation of the underlying data. Finally, we note here that the use of a Heckman specification to control for the use of stock options is not justified for our data by a likelihood ratio test.

Other control variables included in our empirical analysis are a market return volatility measure, a set of indicator variables capturing the 2-digit NAICS industry of the firm, and a time trend variable. For each year, the return volatility measure is calculated as the standard deviation in the overall monthly return for S&P 500 firms over the previous 60 months as reported in data provided by the Center for Research in Security Prices (CRSP). Barron and Waddell (2003) suggest that this aggregate measure can provide a reasonably clean measure of the extent of exogenous market shocks.[28]

Finally, our analysis up to this point has been static in nature, as we have not considered the effect on incentives of past accumulations of options and restricted stock. To control for the potential influence of past compensation packages on the optimal proportion of current equity compensation offered as options, we construct a measure of the value of the executive's past awards of options as a proportion of the value of total equity holdings from past awards. As the proxy statement reports 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 that we treat all existing options as a single grant with a five year remaining term and an exercise price such that the intrinsic value is equal to that reported in the proxy statement, adopting 10-year Treasury bond rates as the risk-free rates of return.[29] Having done so, we impute a Black-Scholes value for existing options using the dividend yield for the company reported in *ExecuComp* and calculate the standard deviation of monthly stock returns for each company using data from CRSP. We use monthly total returns to shareholders over the sixty months preceding each sample year.[30]

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[28] Both age and tenure are not well reported in the *ExecuComp* data and we therefore chose not to report the results for the sub-sample of executives for which this information was available. Note that for the sub-sample for which such variables were available, we found no effect of tenure on the proportion of equity awarded in the form of stock options. We did find, however, that the proportion was decreasing at a decreasing rate with respect to age. The qualitative results reported in Table 2 are robust to the inclusion of either tenure or age.

[29] The risk-free interest rates used for 1992 through 2000 were 7.01, 5.87, 7.08, 6.58, 6.44, 6.35, 5.26, 5.64 and 6.03 percent.

[30] Results are robust to an alternative measure of the incentives from the executive's prior equity holdings using measures of the executive's pay-performance sensitivities of stock and option holdings. For stock holdings, this is

4.3. Results

Table 3 reports the results of empirical tests of hypotheses 1 through 4. Columns (1) and (2) reports these results for a pooled sample of executives and Column (3) reports these results controlling for executive-firm fixed effects. As predicted by our theory (Hypothesis 1), we find that the higher is an executive within a firm in our sample, the less likely the executive is to have a given dollar of equity compensation awarded in the form of stock options. In light of our theory of decision making and earlier evidence that more-senior executives tend to receive proportionately more incentive pay and more of their incentive pay directly linked to the value of the firm (Barron and Waddell, 2003), this systematic leaning toward a particular type of equity compensation is intriguing. Pooled-data estimates on our full sample (Column (2) of Table 3) suggest that relative to an executive who's proportional-rank measure is at the median of the lower quartile, the executive who's proportional-rank measure is at the median of the upper quartile (i.e. the firm's top executive in all cases) is 1.9 percent less likely to receive a given dollar of equity compensation as stock options.

This result of proportionately lower stock option pay at more senior positions is consistent with the conjecture that executives in positions of different rank face systematic differences in the types of proposals received, with more senior executives evaluating projects with greater costs attached to mistakes.[31] However, one might argue that this empirical result may instead reflect differences in risk aversion across executives, with executives in more senior positions being less risk averse. It can be the case that the optimal proportion of equity-compensation that is option based will increase with a decrease in the executive's aversion to risk. If we accept the view that executives of different ranks are paid differently solely due to differences in their aversion to risk, then there would be no predicted change in the equity-compensation for the same executive who changes rank over time. However, the estimation result for the fixed-effect model (Column (3) of Table 3) that controls for

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simply the fraction of the firm that the executive owns. For options, however, we first impute the value of options held and then calculate the option delta, multiplying this by the fraction of the firm's stock on which the options are written to yield a pay-performance sensitivity from options as in Aggarwal and Samwick (2003) and others.

[31] These results are also consistent with those of Barron and Waddell (2003) who find proportionately higher incentive pay and proportionately greater equity-based incentive pay at more senior positions.

unobserved executive-firm effects also suggests an increase in the proportion of equity compensation with a move to a higher rank within the firm, with a move from the median of the lower quartile to the median of the upper quartile increasing the probability of receiving a given dollar of equity compensation as stock options by 4.8 percent.

Hypothesis 2 identifies firm size as another important potential determinant of the use of stock options. The results reported in Table 3 also support this claim. Executives at larger firms, although they receive more equity-based compensation (Barron and Waddell, 2003), tend to receive less equity in the form of options. Specifically, an executive employed in a firm that is at the median of the upper quartile in assets is 9.7 percent less likely to receive a given equity-compensation-dollar as stock options than an executive in a firm at the corresponding median of the lower quartile. However, while the point estimate of the fixed-effect specification is of the same sign, results reported in Column (3) suggest no significant relationship between firm size and the breakdown of equity into stock options and restricted stock. In other words, within our sample, the finding that firms adjust the mix of equity awards in response to changes in size is properly thought of as cross-sectional.

Hypothesis 3 links the increased use of stock options to firms with greater R&D expenditures that arises from the greater gains to evaluating projects at such firms, and we find support for this hypothesis. For our pooled sample, an executive employed in a firm that is at the median of the upper quartile in R&D intensity is 4.7 percent more likely to receive a given dollar of equity compensation as stock option than an executive employed in a firm that is at the median of the corresponding lower quartile. However, note that the fixed-effect model reports no significant change in the use of options over restricted stock when a given firm becomes more or less research intensive.[32]

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[32] Note the 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.

Finally, Hypothesis 4 suggests that when project returns are more likely to appear in the form of dividend than in stock price appreciation, the setting of an exercise price equal to the current market value is more likely to result in an exercise price set “too high,” and thus to a reduced use of options. For our pooled sample, this in fact appears to be the case. Firms that pay dividends in one year are 1.8 percent less likely to award a given equity-compensation dollar as stock options in the following year. However, as with the research and development variable, the result for the pooled sample does not carry over to the fixed-effect estimation results.

4.4. Nonconformity to standard exercise value practice and the use of options

Our analysis above presumes that some firms are constrained to award options at the money and that it is due to this constraint that restricted stock is awarded to executives in place of options. The *ExecuComp* dataset reports the details of individual option awards made to each executive within the sample in each year. As such, we are able to identify when stock options with premium and discount exercise prices are awarded (compared to at the money). As a measure of the degree to which options are awarded to an executive either as premium or discount options, we use the average ratio of exercise price to grant-date market price weighted by the number of units awarded at each exercise price. Thus our measure equals one when all awards made to an executive in a given year are made at the money. When at least one award is made either in the money or out of the money, our ratio adjusts either downward or upward, the degree depending on the number of units awarded away from the money relative to that awarded at the money.

Recall that for the entire sample of executives between 1992 and 2000, 77,465 option awards of a possible 81,118 awards were made at the money. We have argued that this degree of conformity suggests a potential constraint in the setting of exercise prices. It follows that when one observes nonconformity (i.e. setting exercise prices not equal to the grant-date market value of the firm), the constraint is not binding and we should thus observe an increase in the use of options. Such cases of a non-binding constraint presumably reflect situations where the costs to deviating from the rule-of-thumb behavior in setting the exercise price are low. We therefore hypothesize the following:

> **Hypothesis 5:** If stock options are not awarded to an executive at the money, then stock options will account for a larger proportion of the executive's equity compensation.

Column (4) of Table 3 reports the results of the previously estimated equations with the addition of a measure of how exercise prices are set for each executive. As this information exists only where options are awarded, being included 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 theory suggests that stock options are less likely to be used if the rule of thumb of setting $V^E = V^C$ results in "too high" an exercise value being set. It follows that if $V^E < V^C$ (in the money), then such cases in particular should be ones where the adjustment of the exercise price enhances the use of options. 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 by 4.4 percentage points.[33]

Somewhat surprisingly, we also find evidence that flexibility 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 only by 1.3 percentage points. Nevertheless, we view these findings as generally supportive for our theory that suggests 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.

5. Option Use and the Subsequent Likelihood of Extreme Firm Returns

We now consider the potential relationship between the use of stock options and realized outcomes to decision-making. In particular, we are interested in the correlation between the use of options and the ex post likelihood that the subsequent rate of return for the firm is either very high

[33] Further, there is additional evidence (not reported) that the larger is the average difference between exercise price and grant-date market price on option awards, the larger is the stock-option proportion of equity compensation.

or very low. Our analysis suggests that, other things equal, the replacement of stock grants with options would lead to more extreme returns. This is not surprising. A general feature of options is that they provide an executive with the incentive to lower his or her standard for plan adoption, and a lower standard means the agent is more likely to adopt a new plan of unknown value to the firm. This translates into a tendency for firms that rely more heavily on options to be more prone to the random arrival of "good" and "bad" plans, realizing more frequently the high returns associated with good plans as good plans are accepted with higher probability, but also realizing more frequently the low returns associated with bad plans as bad plans are also accepted with higher probability.

Table 4 reports the result of multinomial Logit model of the likelihood a firm's return (including dividend payments) over the subsequent three-year period will populate either the upper or lower 20 percent of returns across all firms in the sample, relative to the middle 60 percent of the distribution. Although for simplicity our theory has focused on the distortion effects of options compared to restricted stock grants, in the empirical analysis we consider all compensation, not just equity-based compensation. Measuring the extent of option use in terms of the proportion of total compensation that is options allows us to include those executives and firms that do not have equity-based compensation. The first two columns of Table 4 report the correlation between outcomes and the proportion of total compensation across the top five executives at the firm that is in the form of stock options. The results do indicate that returns are more extreme when options are a larger part of executive compensation.

However, it is important to realize that our analysis of the optimal form of equity-based compensation suggests that differences in the use of options across firms are not randomly assigned, but instead can reflect systematic differences in the underlying parameters that define the degree to which the at-the-money rule of thumb for setting the exercise value binds. The predicted effect of option use on firm performance must therefore also account for the effect of such parameter changes on extreme returns. For instance, our simulations suggest that for some parameter changes considered in Section 3.3, such as an increase in the difference between good and bad projects, the resulting tendency to reduce the use of options is not sufficient to overcome the increase in extreme outcomes arising from the underlying different parameter values. However, for other parameter changes, such as a decrease in the variance of the signal on project type coupled with a reduced gain from increased evaluation effort, the resulting tendency to reduce the use of options can result in a reduction in extreme outcomes.[34]

In the second two columns in Table 4, we report an expanded specification of the determinants of extreme returns that includes controls for characteristics of the firm that can influence the option choice. In short, we still find that the larger is the proportion of compensation that is awarded to the team of top executives in the form of stock options in a given year the higher is the likelihood that the firm will populate the tails of the overall distribution of firms with regard to the realized returns over a subsequent three-year period. Comparing the median of the lower and upper quartiles, where the proportion of total compensation across the top five executives at the firm is more heavily option based, firms are 41.2 percent more likely to have realized a subsequent three-year return that is in the lowest 20 percent of firm returns. Using the same comparison, firms are also 17.8 percent more likely to have realized a subsequent three-year return that is in the highest 20 percent of firm returns.[35] These results suggest an important pattern in firm performance that can be linked to stock option use.

6. Conclusion

The model of plan selection developed in this paper introduces a benefit to compensating executives with options. By leveraging a given expected compensation in the form of stock into a

[34] It is important to recognize that in our simulations, the current market value of the firm is adjusted for any parameter changes so that the expected rate of return is unaffected by parameter changes.
[35] Firms are therefore 15.2 percent less likely to have realized a subsequent three-year return that is in the middle 60 percent of firm returns.

larger number of stock options, option compensation provides greater incentive for the agent to determine the true value of the plan being proposed. In short, while options are often viewed as creating investment distortions, the model identifies that, on net, options can lead to better decision making in so far as the decision-maker is encouraged to invest greater effort in determining the unknown project's value to the firm. A novel element of the model is that it does not rely on risk considerations in identifying an important role for stock options in executive compensation.

However, when the principal's choice of the exercise price is constrained to be too high relative to first-best, the leverage value of options is outweighed by the costs associated with option-induced distortion. Firms will then find it optimal to award some equity-based 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. Simulations of the model indicate that an exercise price that is higher than what is optimal from an incentive stand point can occur if the firm follows an at-the-money rule for setting the exercise price.[36]

We have argued that the greater the executive's importance at the firm, the larger the firm, the less research intensive the firm, and the more dividends rather than stock appreciation are the source of stockholders' return, the lower is the optimal exercise value relative to the current market value of the firm. As such, if there is a constraint on the setting of the exercise value at the money, each of these changes makes it more likely that the exercise value will be "too high," such that a gain to replacing stock options with restricted stock is more likely. Empirical evidence supports this view, as options are more heavily used at lower executive ranks, in smaller firms, in firms with a recent no-dividend policy, and in more research-intensive organizations. Consistent with this discussion, we also find direct evidence of a systematic increase in the use of options conditional on options not being awarded at the money.

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[36] Note, again, that Hall and Murphy (2000) also suggests that the optimal exercise price is in the money, yet for different reasons related to option valuation and the manager's risk aversion.

In general, our theory suggests that the use of options induces executives to be more willing to try uncertain new plans, other things equal. Controlling for key firm characteristics, our finding of a systematic increase in the likelihood that the firm realizes a future return in either tail of the distribution of average firm returns when the top executives' compensation includes a larger proportion of stock options supports this view. [37]

Abstracting away from of alternative types of incentive schemes (such as comparative performance evaluation, tournament incentives, and bonuses based on accounting measures), this paper has focused on two common methods of tying an executive's wealth to firm value, with a particular view of how decisions are made within organization.[38] While we anticipate that the fundamental tradeoff identified in this paper is likely to remain in future modifications, one important feature of future research will be to further expand the nature of the executive's problem. Currently, we have executives choosing evaluation effort and the criteria for adopting the status quo versus a given alternative, uncertain, project. However, executives likely influence the set of projects they evaluate, and we plan on adding features such as this to future analysis. Further, one could consider modeling the decision-making process as hierarchical, with proposals endogenously rising through a chain of command.[39]

Of the total option grants made to employees in the 1990s, "managers and employees below the five top executives have received an increasing share," accounting for 90 percent of awards made in 2002 (Hall and Murphy (2003)). Our particular focus has been on the very highest of decision

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[37] This outcome is consistent with observations in the popular press. The *Wall Street Journal* recently ran an article titled "High Profiles in Hot Water," providing a list of nine companies, and twelve executives in particular, who are in "hot water" (Friday June 28, 2002, page B1). From this list of companies, five appear in the S&P 500, S&P Midcap 400 or S&P Smallcap 600, and thus are in Standard & Poor's *ExecuComp* dataset, which details the compensation of the top five executives at these companies as reported on company proxy statements. Interestingly, between 1992 and 2000, the top five executives in these companies received significantly more equity compensation in the form of stock options than did executives at comparable companies.

[38] For recent papers that consider compensation in a tournament setting, see Main, O'Reilly III, and Wade (1993), Eriksson (1999), and Bognanno (2001). For papers that

[39] Further still, alternative approaches to decision making could include committee decisions as opposed to individual decision makers. See Koh (1994) for discussion of such an approach.

makers within the largest of US firms, so considering the model's implications for lower-level employees may be fruitful. If such an analysis allowed for an explicit separation of the roles of information gathering and decision making (with lower-ranking workers focused on information gathering), the leveragability of options at lower ranks with no offsetting investment distortion may explain the wide use of options in middle management. However, one suspects that it is at these lower management levels that risk considerations are of increased importance, and so should be incorporated into an analysis of stock option compensation for middle managers.[40]

[40] An interesting paper that does focus on risk considerations in the use of options for middle managers is the paper by Oyer and Schaefer (2003). This paper suggests a significant cost to options in terms of the risk premia middle managers require with options, and also introduces a sorting role for options. For a discussion of productivity changes related to the granting of broad-based stock options see *Stock options, corporate performance, and organizational change*, The National Center for Employee Ownership, 2002.

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Table 1

Use of options versus restricted stock grants.

Sample of top-five executives from *ExecuComp* for the years 1992-2000.

Year	Percent of executives with some equity-based compensation	Number of (top-5) executives in full sample	Number of firms in full sample	For those with equity-based compensation, proportional breakdown of equity into stock options and restricted stock: Percent with only options	Percent with both options and restricted stock	Percent of equity awarded as options	Number of top 5 executives with equity-based compensation	Number of firms with equity-based compensation
1992	63.52%	5,724	1,396	74.04%	16.89%	83.23%	3,636	994
1993	70.96%	7,563	1,634	75.98%	16.96%	85.41%	5,367	1,333
1994	73.02%	8,063	1,685	76.14%	18.16%	87.26%	5,888	1,404
1995	73.42%	8,313	1,741	74.24%	19.79%	85.73%	6,103	1,454
1996	77.68%	8,876	1,886	74.85%	19.26%	86.50%	6,895	1,653
1997	78.34%	9,158	1,942	75.80%	19.19%	87.53%	7,174	1,709
1998	81.02%	9,197	1,927	75.05%	20.19%	87.64%	7,451	1,750
1999	82.23%	8,761	1,798	76.86%	19.73%	89.90%	7,204	1,649
2000	84.58%	7,147	1,456	74.26%	21.99%	88.03%	6,045	1,358
Overall	76.60%	72,802	15,465	75.32%	19.30%	87.07%	55,763	13,304

Table 2

Variable definitions and summary statistics.

Statistics for the sample of 55,763 executive-year observations for which equity was granted to the executive. 2,407 firms represented. The sample period is 1992-2000.

Variable	Units	Definition (source)	Mean (standard deviation)
Executive proportional rank	Ratio	Ratio of each executive's total compensation to the top executive's compensation at the firm in the same year (*ExecuComp*)	0.565 (0.298)
Firm book value of assets	Millions of dollars	Book value of physical plant, inventories, and investments in unconsolidated subsidiaries in millions of 1999 dollars (*ExecuComp*)	9,526.9 (35,640.3)
Firm ratio of research and development to book value of assets	Ratio	Ratio of research and development expenditures to book value of assets, both in 1999 dollars (Compustat)	0.031 (0.114)
Firm paid dividend in prior year	0, 1	Indicator that firm paid dividend in preceding fiscal year (*ExecuComp*)	.611 (.487)
Firm prior-three-year return	Proportion	Firm's prior 3 year total return to shareholders, including the monthly reinvestment of dividends (*ExecuComp*)	0.170 (0.292)
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)	.035 (.007)
Value of executive's prior option holdings	Millions of dollars	Imputed Black-Scholes value of options held in millions of 1999 dollars (*ExecuComp*)	4.936 (22.9)
Value of executive's prior stock holdings	Millions of dollars	Value of stock held in millions of 1999 dollars (*ExecuComp*)	169.4 (3,856.5)
Firm industry indicators	0, 1	Indicator variables: 2-digit North American Industry Classification System industries (Compustat)	
Trend	1 to 9	Time-trend variable reflecting years 1992 through 2000	

Table 3

The extent of option-based equity compensation.

Reported coefficients for Columns (1), (2) and (4) are probability derivatives from the estimation of Probit models where we allow for observations to be independent across executive-firm combinations but not necessarily independent within these combinations. Reported coefficients for Column (3) are estimated coefficients. Absolute values of z-statistics are in parentheses. The Huber-White sandwich estimator of variance is used. Coefficients for industry indicator variables are available from the authors.

	Executives who receive equity compensation			Executives who receive stock options
Independent variable	Likelihood that a given dollar of equity compensation is option-based (Probit)		Fixed-effect model for proportion of equity compensation that is option-based	Likelihood that a given dollar of equity compensation is option-based (Probit)
	(1)	(2)	(3)	(4)
Executive proportional rank	-0.016	-0.021	-0.056	-0.015
	(2.71)***	(3.47)***	(8.41)***	(3.75)***
Log of firm book value of assets	-0.019	-0.020	-0.004	-0.017
	(16.03)***	(15.93)***	(1.01)	(21.39)***
Firm ratio of research and development to book value of assets	0.537	0.517	0.014	0.261
	(10.47)***	(10.20)***	(1.15)	(8.09)***
Firm paid dividend in prior year	-0.018	-0.018	0.007	-0.010
	(5.60)***	(5.77)***	(2.77)***	(4.54)***
Firm prior-three-year return	0.016	0.010	-0.014	0.009
	(3.25)***	(1.80)*	(3.09)***	(2.58)***
Indicator that return variable missing [a]	0.021	0.022	0.007	0.011
	(4.43)***	(4.57)***	(1.21)	(3.53)***
S&P 500 60-month return volatility	0.263	0.217	0.380	0.270
	(1.66)*	(1.37)	(2.51)**	(2.47)**
Trend (1992 = 1)	0.006	0.005	0.006	0.001
	(10.81)***	(9.28)***	(8.37)***	(2.06)**
Value of prior option holdings [b]		0.001	-0.000	0.001
		(2.28)**	(1.27)	(4.46)***
Value of prior stock holdings		0.000002	0.000	0.000
		(2.99)***	(0.52)	(2.66)***
Executive received stock options in the money				0.044
				(7.62)***
Executive received stock options out of the money				0.013
				(1.97)**
NAICS industry indicator variables included	Yes	Yes	No	Yes
Constant			0.883	
			(34.75)***	
Observations	55,763	55,763		52,761
Observations / number of unique firm-executive combinations			55,763 / 18,811	
	Wald $\chi2(29) = 1202.4$	Wald $\chi2(31) = 1213.4$	F(10, 36942) = 19.57	Wald $\chi2(33) = 1309.0$

[a] Where missing, we substitute the average three-year return from the sample of non-missing observations.
[b] Company proxy statements report only the aggregate number of options and the aggregate intrinsic value of previously awarded options that are in the money. As such, we follow Murphy (1999) in imputing the Black-Scholes value of existing stock options. (Details in text).
* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Table 4

The effect of option-based compensation across the top 5 executives on extreme rates of returns over the subsequent three years

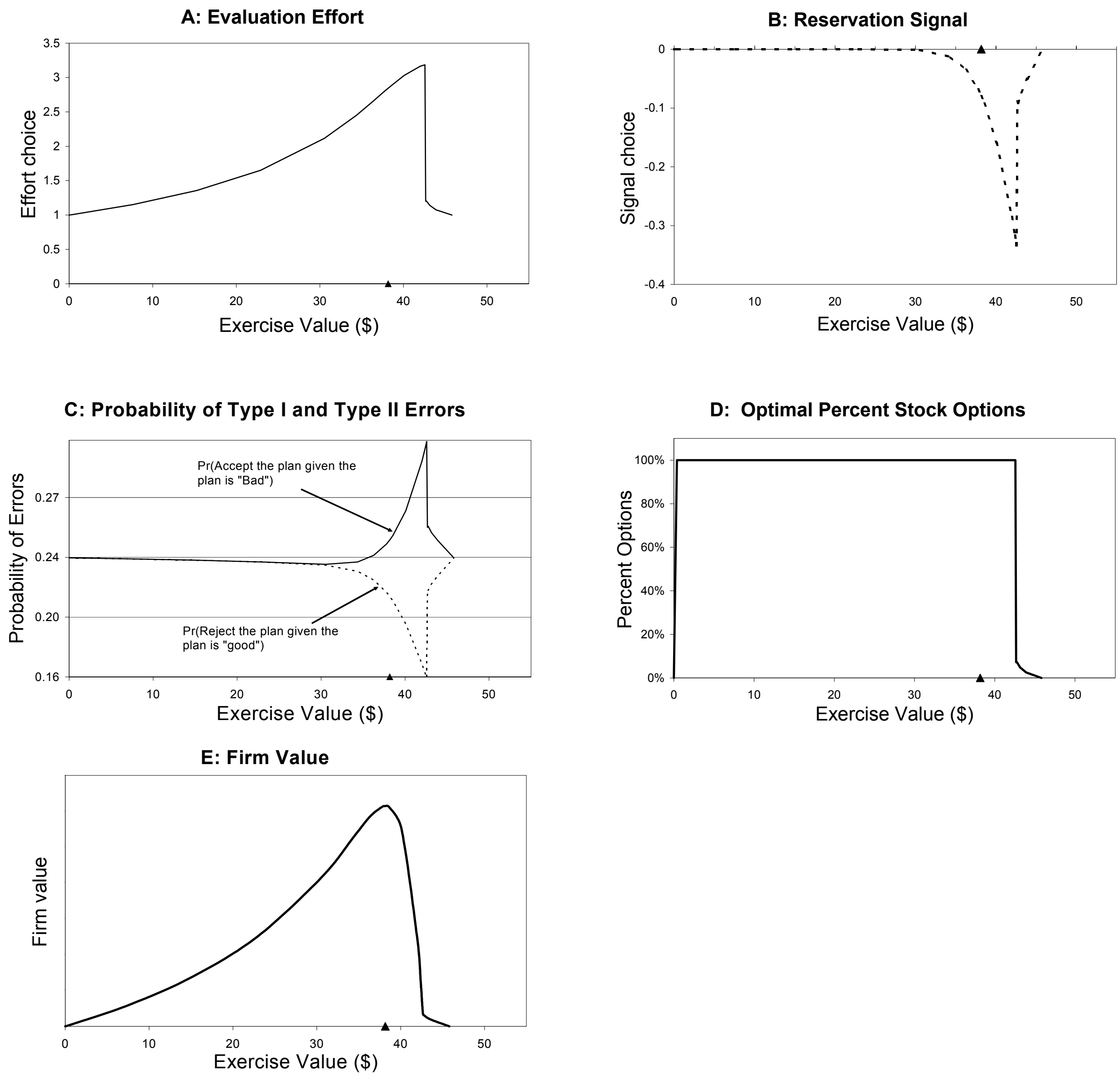
Reported coefficients are from the estimation of a multinomial Logit model of a firm's future rate of return (including dividends) over the subsequent three-year period that takes one of three values: top 20% of returns, middle 60% of returns, and bottom 20% of returns. Reported coefficients for all columns are estimates of the likelihood of being in the bottom 20% and top 20%, respectively. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Coefficients for industry indicator variables and variables that interact the firm-level proportion of compensation awarded as options with the number of top five executives used to form this proportion are available in a supplement. Results are robust to controls for the level of equity holdings among the team of top executives. These controls are not included as they are insignificant in determining extreme returns. The independent variables represent firm-level data for the seven years from 1992 to 1998. The return data used to create the three categories of returns for each year covers the ten years from 1992 to 2001.

Independent variable	Likelihood subsequent 3-year return among bottom 20% of returns, relative to middle 60% (1a)	Likelihood subsequent 3-year return among top 20% of returns, relative to middle 60% (1b)	Likelihood subsequent 3-year return among bottom 20% of returns, relative to middle 60% (2a)	Likelihood subsequent 3-year return among top 20% of returns, relative to middle 60% (2b)
Proportion of total compensation among the top 5 executives that is option-based	1.253	1.220	1.063	0.680
	(8.91)***	(7.69)***	(6.94)***	(3.99)***
Log of firm book value of assets			-0.280	-0.132
			(10.29)***	(4.36)***
Firm ratio of research and development to book value of assets			-0.133	3.714
			(0.17)	(4.92)***
Firm paid dividend in prior year			-0.223	-0.357
			(2.93)***	(4.17)***
Firm prior-three-year return			0.482	-0.037
			(4.06)***	(0.27)
S&P 500 60-month return volatility			4.404	-15.232
			(0.70)	(2.15)**
Trend (1992 = 1)			0.008	-0.038
			(0.28)	(1.17)
NAICS Industry indicator variables included	No	No	Yes	Yes
Controls for number of executives contributing to firm-level proportion that is option-based	Yes	Yes	Yes	Yes
Constant	-1.499	-1.784	0.363	0.020
	(25.62)***	(28.26)***	(0.91)	(0.05)
Observations	8,537		8,537	
	Wald $\chi 2(10) = 165.6$		Wald $\chi 2(64) = 5{,}795.2$	

* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Figure 1

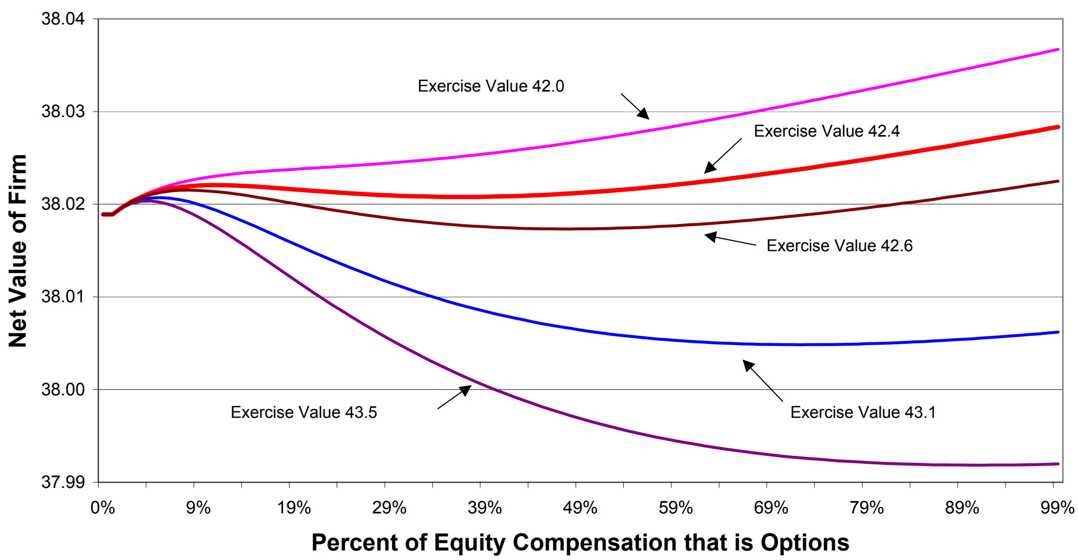
Effects of Changes in the Exercise Value on Effort (A), Reservation Signal (B), Probability of Type I and Type II Errors (C), Optimal Percent of Compensation that is Options (D), and Net Firm Value (E)



The triangle on the axis of each of the above figures indicates the unique optimal exercise value. This corresponds to the highest value of the firm, as illustrated by Figure E. Figure A indicates that as the exercise value increases from zero, the leverage effect of options provides an increasing level of effort, increasing the net value of the firm (Figure E). However, as Figure B indicates, the increasing exercise value introduces distortions in the reservation signal from first-best levels (zero), and eventually leads to a significant increase in type II errors (accepting a bad project) as shown in Figure C. At some point, the exercise price so high that these distortions become too great to offset the gains from the effort enhancement of options. At that point, the use of options is effectively discontinued, as illustrated in Figure D.

Figure 2

Effect on Firm's Net Value of Increases in the Percent of Equity Compensation that is Options for Various Exercise Values



The figure illustrates that as the exercise value increases, the optimal compensation package suddenly switches from all options to almost entirely restricted stock grants. This "knife-edge" result occurs at an exercise value of approximately 42.6 for our bench-mark simulation parameters, as illustrated in Figure 1, Panel D. Below this critical exercise value (e.g., at 42.0 and 42.4), the optimal compensation package is all options. At an exercise value of 42.6, the figure illustrates that the increase in firm value arising from increased evaluation effort when options are initially introduced is reversed by the distortion effects on the reservation signal as the amount of options grows. However, the continual increase in effort that options provide ultimately overcomes these distortions, such that the firm is essentially as well off with a compensation package that has few options as with one that is all options. Above this critical exercise value (e.g., at 43.1 and 43.5), the effort induced by an all-option compensation package cannot overcome the losses from distortions, and the optimal compensation package becomes one dominated by restricted stock grants.

"Work hard, not smart: Stock options as compensation"
by John M. Barron and Glen R. Waddell

Supplement A: The Principal Agent Model and Conditions for the Use of Options

Below we provide a formal statement of the principal's maximization problem when both stock options and stock grants can be included as part of the agent's compensation package. We then show conditions under which the principal will include options in the compensation package. We do so by establishing conditions under which the stock option portion of compensation has an optimal exercise value greater than zero. In our discussion, we omit references to a position of type *r* to simplify notation.

In the general model, following Holmström (1979), the principal's problem for the case of a single agent is:

(1) $$\max_{\delta\ ,\beta^R,\beta^O,V^E,e,\hat{s}} \rho \mathrm{E}[V]-E[C]$$

subject to a variety of constraints. First, there are the incentive compatibility constraints with respect to the agent's choice of effort that affect the precision of the signal and the agent's choice of reservation signal that determines which new projects are adopted:

(2) $$\rho\left[-\frac{\partial F_G}{\partial e}(\beta^R+\phi^I\beta^O)k^I \ +\frac{\partial F_B}{\partial e}(\beta^R+\phi^{II}\beta^O)k^{II}\right]-e=0 \quad \text{and}$$

(3) $$\rho\left[-\frac{\partial F_G}{\partial \hat{s}}(\beta^R+\phi^I\beta^O)k^I \ +\frac{\partial F_B}{\partial \hat{s}}(\beta^R+\phi^{II}\beta^O)k^{II}\right]=0 \quad .$$

Then there is the individual rationality constraint to assure the agent finds the employment contract advantageous given the utility *u* to the best alternative:

(4) $E(C)-e^2/2-u=0$,

Finally, there are the non-negativity constraints on δ , β^R, β^O, V^E, and e. Let ω_e , ω_s , and λ denote the Lagrange multipliers for the two incentive compatibility constraints ((2) and (3)) and the individual rationality constraint (4), respectively. Let τ_i , $i=\delta$, β^R, β^O, and V^E denote multipliers associated with the non-negatively constraints. Recall that in the above problem:

(5) $\mathrm{E}[V] = \alpha V^G + (1-\alpha)V^o - F_G k^I - (1-F_B)k^{II}$,

(6) $k^I = \alpha(V^G - V^o)$,

(7) $k^{II} = (1-\alpha)(V^o - V^B)$,

(8) $\mathrm{E}[\mathrm{V_O}] = \alpha \int_{V^E}^{\bar{V}} (x-V^E)h^G(x)dx + (1-\alpha)\int_{V^E}^{\bar{V}} (x-V^E)h^o(x)dx - \left(F_G\phi^I k^I + (1-F_B)\phi^{II}k^{II}\right)$,

(9) $\mathrm{E}[C] = \delta + \rho(\beta^R E[V] + \beta^O E[V_O])$,

(10) $\phi^I = \int_{V^E}^{\bar{V}} (x-V^E)(h^G(x)-h^o(x))dx/(V^G - V^o)$, and

(11) $\phi^{II} = \int_{V^E}^{\bar{V}} (x-V^E)(h^o(x)-h^B(x))\,dx/(V^o - V^B)$,

The maximization problem includes the following first order condition with respect to the salary component of compensation, δ:

(12) $-1+\lambda+\tau_\delta = 0$.

We assume the non-negative constraint on salary is binding ($\tau_\delta > 0$), such that incentive pay is limited and the incentive compatibility constraint with respect to effort is binding ($\omega_e > 0$). Substituting (12) into the first-order conditions for β^R, β^O, and V^E, we then have the following first-order conditions for these three choice variables of the compensation package (extent of stock and options in the compensation package and the exercise value attached to options) as well as for the first-order conditions for the level of effort and the reservation signal:

(13) $-\tau_\delta \rho E[V] + \omega_e \rho\left(-\frac{\partial F_G}{\partial e}k^I + \frac{\partial F_B}{\partial e}k^{II}\right) + \omega_s \rho\left(-\frac{\partial F_G}{\partial \hat{s}}k^I + \frac{\partial F_B}{\partial \hat{s}}k^{II}\right) + \tau_{\beta^R} = 0$

$$(14)\ -\tau_\delta \rho E[V_O] + \omega_e \rho\left(-\frac{\partial F_G}{\partial e}\phi^I k^I + \frac{\partial F_B}{\partial e}\phi^{II} k^{II} \right) + \omega_s \rho\left(-\frac{\partial F_G}{\partial \hat{s}}\phi^I k^I + \frac{\partial F_B}{\partial \hat{s}}\phi^{II} k^{II} \right) + \tau_{\beta^O} = 0$$

$$(15)\ -\tau_\delta \beta^O \rho E[V_O]' + \omega_e \rho\beta^O\left(-\frac{\partial F_G}{\partial e}\phi^{I'} k^I + \frac{\partial F_B}{\partial e}\phi^{II'} k^{II} \right) + \omega_s \rho\beta^O\left(-\frac{\partial F_G}{\partial \hat{s}}\phi^{I'} k^I + \frac{\partial F_B}{\partial \hat{s}}\phi^{II'} k^{II} \right) + \tau_{V^E} = 0$$

$$(16)\ \begin{aligned} &\rho\left[-\frac{\partial F_G}{\partial e}k^I + \frac{\partial F_B}{\partial e}k^{II} \right] + \omega_e \rho\left[-\frac{\partial^2 F_G}{\partial e^2}(\beta^R + \phi^I\beta^O)k^I + \frac{\partial^2 F_B}{\partial e^2}(\beta^R + \phi^{II}\beta^O)k^{II} - 1 \right] \\ &\qquad + \omega_s \rho\left[-\frac{\partial^2 F_G}{\partial \hat{s}\partial e}(\beta^R + \phi^I\beta^O)k^I + \frac{\partial^2 F_B}{\partial \hat{s}\partial e}(\beta^R + \phi^{II}\beta^O)k^{II} \right] = 0 \end{aligned}$$

$$(17)\ \begin{aligned} &\rho\left[-\frac{\partial F_G}{\partial \hat{s}}k^I + \frac{\partial F_B}{\partial \hat{s}}k^{II} \right] + \omega_e \rho\left[-\frac{\partial^2 F_G}{\partial e\partial \hat{s}}(\beta^R + \phi^I\beta^O)k^I + \frac{\partial^2 F_B}{\partial e\partial \hat{s}}(\beta^R + \phi^{II}\beta^O)k^{II} \right] \\ &\qquad + \omega_s \rho\left[-\frac{\partial^2 F_G}{\partial \hat{s}^2}(\beta^R + \phi^I\beta^O)k^I + \frac{\partial^2 F_B}{\partial \hat{s}^2}(\beta^R + \phi^{II}\beta^O)k^{II} \right] = 0 \end{aligned}$$

where

$$(18)\ E[V_O]' \equiv \frac{\partial E[V_O]}{\partial V^E} = -\alpha\int_{V^E}^{\bar{V}} h^G(x)dx - (1-\alpha)\int_{V^E}^{\bar{V}} h^o(x)dx - \left(F_G k^I \phi^{I'} + (1-F_B)k^{II}\phi^{II'} \right) < 0$$

$$(19)\ \phi^{I'} \equiv \frac{\partial \phi^I}{\partial V^E} = -\int_{V^E}^{\bar{V}} (h^G(x) - h^o(x))dx / (V^G - V^o) = (F_G(V^E) - F_o(V^E))/(V^G - V^o) \le 0$$

$$(20)\ \phi^{II'} \equiv \frac{\partial \phi^{II}}{\partial V^E} = -\int_{V^E}^{\bar{V}} (h^o(x) - h^B(x))dx / (V^o - V^B) = (F_o(V^E) - F_B(V^E))/(V^o - V^B) \le 0$$

Conditions for the Use of Options

We now explore conditions under which the optimal exercise value is strictly positive, implying that the use of options is optimal. Our approach is to find conditions such that, if $V^E = 0$, the first-order conditions would indicate a contradiction. As we will see, the rationale for $V^E > 0$ reflects the fact that, were $V^E = 0$, a small increase in V^E, given a positive weight on option compensation ($\beta^O > 0$), provides leveraging gains in the sense that the use of options relaxes the extent to which the salary constraint is binding. When $V^E \to 0$, we have $E[V_O] \to E[V]$, $\phi^I \to 1$, $\phi^{II} \to 1$,

(21) $\phi^{I'} \equiv \frac{\partial \phi^{I}}{\partial V^{E}} = (f_G(0) - f_o(0))/(V^G - V^o)$,

(22) $\phi^{II'} \equiv \frac{\partial \phi^{II}}{\partial V^{E}} = (f_o(0) - f_B(0))/(V^o - V^B)$, and,

given $k^I = \alpha(V^G - V^o)$ and $k^{II} = (1-\alpha)(V^o - V^B)$,

(23) $\frac{\partial E[V_O]}{\partial V^E} = -1 - \alpha F_G(f_G(0) - f_o(0)) + ((1-\alpha)(1-F_B))(f_o(0) - f_B(0))$.

For this limiting case of $V^E = 0$, the first order conditions for β^R and β^O become identical and the first-order condition for the sum $\beta^O + \beta^R$ ((13) or (14)), given that the sum is positive, becomes:

(24) $-\tau_\delta \rho E[V] + \omega_e \rho \left(-\frac{\partial F_G}{\partial e} k^I + \frac{\partial F_B}{\partial e} k^{II} \right) = 0$.

Further, the incentive compatibility constraint for effort in (2) becomes:

(25) $\rho(\beta^R + \beta^O)\left(-\frac{\partial F_G}{\partial e} k^I + \frac{\partial F_B}{\partial e} k^{II} \right) - e = 0$,

the incentive compatibility condition for the reservation signal in (3) becomes:

(26) $\rho(\beta^R + \beta^O)\left[-\frac{\partial F_G}{\partial \hat{s}} k^I + \frac{\partial F_B}{\partial \hat{s}} k^{II} \right] = 0$,

and, finally, the first-order condition for V^E in (15) becomes:

$$\begin{aligned}
&\tau_\delta \rho \beta^O \left(1 + \alpha F_G(f_G(0) - f_o(0)) + (1-\alpha)(1-F_B)(f_o(0) - f_B(0))\right) \\
(27) \quad &+ \omega_e \rho \beta^O \left(-\alpha \frac{\partial F_G}{\partial e}(f_G(0) - f_o(0)) + (1-\alpha)\frac{\partial F_B}{\partial e}(f_o(0) - f_B(0)) \right) \\
&+ \omega_s \rho \beta^O \left(-\alpha \frac{\partial F_G}{\partial \hat{s}}(f_G(0) - f_o(0)) + (1-\alpha)\frac{\partial F_B}{\partial \hat{s}}(f_o(0) - f_B(0)) \right) + \tau_{V^E} = 0
\end{aligned}$$

Through (27) we can identify various conditions under which options will be used. The simplest case is if $f_B(0) = f_o(0) = f_G(0)$, for then (27) simplifies to:

(28) $\tau_\delta \rho \beta^O + \tau_{V^E} = 0$

Condition (28) cannot hold given a binding non-negativity constraint on salary ($\tau_\delta > 0$), the use of options $\beta^O > 0$ and the fact that $\tau_{V^E} \geq 0$. Thus we have a contradiction of the first-order conditions if $V^E = 0$, and it follows that the optimal V^E is strictly positive. To see why this is the case, note that one can interpret the first term in (28) as identifying a "leveraging" gain to an increase in the exercise value from zero. This leveraging gain arises as an increase in V^E lowers the expected payment to a given number of options, and thus more options can be included in the contract. An increase in the number of options induces the agent to choose an effort level closer to first-best. Note, however, that a key element of this argument is the condition $f_B(0) = f_o(0) = f_G(0) = 0$, such that the increase in the exercise value from zero has no effect on the incentives to provide effort other than by allowing an increase in the number of options in the contract.

The more general case would have $f_B(0) \geq f_o(0) \geq f_G(0) \geq 0$. Let $x = f_B(0) - f_G(0)$, with $x \geq 0$ and let $y = f_B(0) - f_o(0)$, with $y \geq 0$. Then (27) can be rewritten as:

$$\text{(29)} \quad \begin{aligned} &\lambda_\delta \rho\beta^O \left(1 - x\alpha F_G + y(\alpha F_G - (1-\alpha)(1-F_B))\right) + \omega_e \rho\beta^O \left(x\alpha \frac{\partial F_G}{\partial e} - y\left(\alpha \frac{\partial F_G}{\partial e} + (1-\alpha)\frac{\partial F_B}{\partial e} \right)\right) \\ &+ \omega_s \rho\beta^O \left(x\alpha \frac{\partial F_G}{\partial \hat{s}} - y\left(\alpha \frac{\partial F_G}{\partial \hat{s}} + (1-\alpha)\frac{\partial F_B}{\partial \hat{s}} \right)\right) + \tau_{V^E} = 0 \end{aligned}$$

In general, the agent's choice of effort and reservation signal are related, as the effort choice affects the precision of the signal and thus the likelihood of type I and type II errors. However, in the case of symmetry in the expected costs of type I and type II errors ($k^I = k^{II}$), the agent's optimal reservation signal is independent of the effort choice. With symmetry, at $V^E = 0$ the agent's choice of reservation signal from (26) implies that $F_G = (1 - F_B)$, $-\partial F_G / \partial e = \partial F_B / \partial e > 0$, $\partial F_G / \partial \hat{s} = -\partial F_B / \partial \hat{s} > 0$ and $\frac{\partial^2 F_G}{\partial e \partial \hat{s}} = \frac{\partial^2 F_B}{\partial e \partial \hat{s}} < 0$. The last condition, coupled with (25), allows us to rewrite (17), the condition for the optimal $\hat{s}$, as

$$\text{(30)} \quad \omega_s \rho(\beta^R + \beta^O)\left[-\frac{\partial^2 F_G}{\partial \hat{s}^2} k^I + \frac{\partial^2 F_B}{\partial \hat{s}^2} k^{II} \right] = 0$$

Satisfying the second-order conditions for the agent's problem requires that $-\frac{\partial^2 F_G}{\partial \hat{s}^2} k^I + \frac{\partial^2 F_B}{\partial \hat{s}^2} k^{II} < 0$. Thus, the condition of symmetry implies from (30) that if $V^E = 0$, then $\omega_s = 0$, which reflects the fact that the reservation-signal incentive compatibility constraint (3) is not binding. Further, if $\alpha = (1-\alpha)$, then (29) simplifies to become:

$$(31) \qquad \lambda_\delta \rho \beta^O \left(1 - x\alpha F_G\right) + \omega_e \rho \beta^O \left(x\alpha \frac{\partial F_G}{\partial e} \right) + \tau_{V^E} = 0$$

Thus, given symmetry as defined above, if $x = f_B(0) - f_G(0)$ is sufficiently small, indicating a small difference in the probability of a zero payoff between a bad and a good project, then condition (31) -- a condition that presumes $V^E = 0$ -- cannot hold given $\beta^O > 0$ and $\tau_{V^E} \geq 0$. This contradiction implies that the optimal V^E is bounded away from zero. In this symmetry case with small *x*, the positive effect on effort from the leverage gain to increasing the exercise value from $V^E = 0$ more than offsets the negative impact on effort from an increase in the exercise value arising from the reduction it has on the cost of errors.

We have indicated two sets of conditions under which the optimal exercise value is positive and thus it is optimal to offer options. A common theme of our discussion is that options provide a leveraging gain given the non-negativity constraint on salary, and that this leveraging gain is the key incentive for the use of options. However, since options by their very nature reduce the agent's concern for bad outcomes, it is not surprising that if the likelihood of these bad outcomes is high and differs significantly by the type of project (good, bad, or status quo), then options may not be optimal.

Options at Optimal Exercise Value Dominate Restricted Stock

If the optimal exercise price is positive, the optimal level weighs the leveraging gains of options against the reduction in effort incentive and the distortion in the reservation signal that arise given a higher exercise value reduces the range of bad outcomes. Condition (15) identifies these gains and costs to an increase in the exercise value. Assuming conditions such that the optimal $V^E > 0$, we now show that at the optimal level for the exercise value, it is not optimal to hold stock grants. That is, we show below that, if $\tau_{\beta^O} = 0$ and $\tau_{V^E} = 0$, then (13), (14), and (15) imply that $\tau_{\beta^R} > 0$, such that $\beta^R = 0$.

To show this, note first that the difference between(13) and (14) is:

(32) $\tau_\delta (E[V] - E[V_O]) = \left(-\left(\omega_e \frac{\partial F_G}{\partial e} + \omega_s \frac{\partial F_G}{\partial \hat{s}} \right) k^I (1-\phi^I) \right) + \left(\left(\omega_e \frac{\partial F_B}{\partial e} + \omega_s \frac{\partial F_B}{\partial \hat{s}} \right) k^{II} (1-\phi^{II}) \right) + \tau_{\beta^R} - \tau_{\beta^O}$

Also, note that for changes in the exercise value,

(33) $\quad E[V_O] = E[V] + \int_0^{V^E} E[V_O]' dV^E$

(34) $\quad \phi^I = 1 + \int_0^{V^E} \phi^{I'} dV^E$

(35) $\quad \phi^{II} = 1 + \int_0^{V^E} \phi^{II'} dV^E$

Substituting (33), (34), and (35) into (32), we can rewrite conditions (13) and (14) as:

(36)

$$-\tau_\delta \int_0^{V^E} E[V_O]' dV^E = \left(\left(\omega_e \frac{\partial F_G}{\partial e} + \omega_s \frac{\partial F_G}{\partial \hat{s}} \right) k^I \int_0^{V^E} \phi^{I'} dV^E \right) - \left(\left(\omega_e \frac{\partial F_B}{\partial e} + \omega_s \frac{\partial F_B}{\partial \hat{s}} \right) k^{II} \int_0^{V^E} \phi^{II'} dV^E \right) + \tau_{\beta^R} - \tau_{\beta^O}$$

If $V^E = 0$ is not optimal, then from (15) we have that at $V^E = 0$,

(37) $-\tau_\delta E[V_O]' + \omega_e \left(-\frac{\partial F_G}{\partial e} \phi^{I'} k^I + \frac{\partial F_B}{\partial e} \phi^{II'} k^{II} \right) + \omega_s \left(-\frac{\partial F_G}{\partial \hat{s}} \phi^{I'} k^I + \frac{\partial F_B}{\partial \hat{s}} \phi^{II'} k^{II} \right) > 0$

For (15) to hold at the optimal $V^E > 0$ then implies that, at the optimal V^E, it must be the case that:

(38) $-\tau_\delta \int_0^{V^E} E[V_O]' dV^E > \left(\left(\omega_e \frac{\partial F_G}{\partial e} + \omega_s \frac{\partial F_G}{\partial \hat{s}} \right) k^I \int_0^{V^E} \phi^{I'} dV^E \right) - \left(\left(\omega_e \frac{\partial F_B}{\partial e} + \omega_s \frac{\partial F_B}{\partial \hat{s}} \right) k^{II} \int_0^{V^E} \phi^{II'} dV^E \right)$

Comparing (36) and (38), it follows that:

(39) $\tau_{\beta^R} - \tau_{\beta^O} > 0$

As it is the case that $V^E > 0$ implies the optimal $\beta^O > 0$, it follows that $\tau_{\beta^O} = 0$. Thus from (39), we have that $\tau_{\beta^R} > 0$. In other words, at the optimal $\beta^O > 0$ and $V^E > 0$, the optimal β^R equals zero. The paper assumes conditions under which options are optimal, and then explores through simulations the effect on the optimal use of options and restricted stock grants if the option value is set at other than its optimal value. In particular, we consider the optimal β^O and β^R if the exercise value is fixed at the current market value. A key finding is that if the resulting option value is too high (above its optimal value), then some compensation in the form of restricted stock can be optimal ($\beta^R > 0$).

"Work hard, not smart: Stock options as compensation"
by John M. Barron and Glen R. Waddell

Supplement B: Parameters for Model Simulations

Table B1 below identifies the parameters adopted for our benchmark simulation case. We use this case not only to determine the optimal exercise value (V^E) and weights for restricted stock and options (β_r^R and β_r^O, respectively), but also to demonstrate various comparative static results regarding the composition of compensation (stock options versus restricted stock grants) if the exercise value is fixed at the current market value of the firm ("at the money").

Table B1: Parameter values assumed for simulation

Variable	Definition	Value
A. Plan characteristics		
α_r	Probability the proposed plan is good.	0.5
V_r^G	Expected value of a good plan.	60
σ_r^G	Standard error of a good plan.	4
V_r^o	Expected value of the status quo.	50
σ_r^o	Standard error of the status quo.	4
V_r^B	Expected value of a bad plan.	40
σ_r^G	Standard error of a bad plan.	4
ρ	Discount factor.[a]	0.74
$h_G, h_o, and\ h_B$	Normal distributions	
B. Signal characteristics		
μ_G	Mean of signal distribution if proposed plan is good.	1
μ_B	Mean of signal distribution if proposed plan is bad.	-1
$\sqrt{1+\upsilon/(1+3e_r)}$	Function linking standard error of signal distribution to agent *r*'s effort.	
υ	Parameter in signal error function.	1
C. Agent characteristics		
u_r	Agent *r*'s alternative utility.	1

[a] This is consistent with an annual real discount rate of 10.5 percent and a three-year delay until the plan value is realized. Such a real discount rate approximates the average annual real return on equity over the 1992 to 2000 period of our sample.

Table B2 indicates the outcome of the simulation for two cases. Part A of Table B2 indicates key characteristics of the "first-best" outcome when the principal can observe the agent's choices. Parts B indicates the optimal compensation package for an agent given the benchmark parameters when the agent's choices cannot be observed ("second-best"). Part C of Table B2 indicates characteristics of the outcome under second-best.

Table B2: Simulation results for benchmark parameter values

A. First-best choices and outcomes (agent's effort and cutoff observed by principal)

Variable	Definition	Value
e_r^*	First-best effort choice.	0.3840
$\hat{s}_r^*$	First-best signal cutoff.	0
$F_G(e_r^*, \hat{s}_r^*)$	Probability of type one error (reject good project).	0.2043
$1 - F_B(e_r^*, \hat{s}_r^*)$	Probability of type two error (accept bad project).	0.2043
$L_r^I = k_r^I / \alpha_r$	Expected cost of type one error.	10
$L_r^{II} = k_r^{II} / \alpha_r$	Expected cost of type two error.	10
$\Phi_r = k_r^I / k_r^{II}$	Ratio of expected losses from Type I and Type II errors.	1
$E[C^*]$	Expected agent compensation.	1.074
$E[V^*]$	Expected value of the firm when value of project realized	52.957
$\rho E[V^*] - E[C^*]$	Expected present value of the firm net of agent compensation.	38.18

B. Parameters of optimal compensation package (second-best)

Variable	Definition	Value
δ	Optimal salary.	0
β^R	Optimal weight for restricted stock.	0
β^O	Optimal weight for options.	0.0924
V^E	Optimal exercise value.	38.18

(continued on next page)

Table B2 (continued)
Simulation results for benchmark parameter values

C. Second-best choices and outcomes (agent's effort and cutoff unobserved by principal)

Variable	Definition	Value
e_r^{**}	Second-best effort choice.	0.07964
$\hat{s}_r^{**}$	Second-best signal cutoff.	-0.07961
$F_G(e_r^{**}, \hat{s}_r^{**})$	Probability of Type I error (reject good project).	0.2110
$1-F_B(e_r^{**}, \hat{s}_r^{**})$	Probability of Type II error (accept bad project).	0.2468
$(\beta_r^R + \phi_r^I \beta_r^O)k_r^I / \alpha_r$	Expected cost of type one error.	.9243
$(\beta_r^R + \phi_r^{II} \beta_r^O)k_r^{II} / \alpha_r$	Expected cost of type two error.	.8464
$\Phi_r^E = \frac{(\beta_r^R + \phi_r^I \beta_r^O)k_r^I}{(\beta_r^R + \phi_r^{II} \beta_r^O)k_r^{II}}$	Ratio of expected losses from Type I and Type II errors.	1.092
$\mathrm{E}(V^O)$	Expected value of firm's options.	14.641
$E[C]$	Expected agent compensation.	1.003
$E[V]$	Expected value of the firm when value of project realized	52.71
$\rho E[V] - E[C]$	Expected present value of the firm net of agent compensation.	38.06