Hard work versus good intentions: Stock options as compensation

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In this paper we contrast the use 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. These decision variables reveal a tradeoff in the use of options. Stock options are attractive in that, for the same expected value as stock grants, they can provide the principal leverage to motivate an executive to undertake more extensive plan evaluation. In short, stock options encourage hard work. However, stock options also bias an executive's decision criteria away from first-best. Our analysis establishes stock options are the preferred form of equity compensation if the exercise price is freely chosen, but also shows that 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: In this paper we contrast the use 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. These decision variables reveal a tradeoff in the use of options. Stock options are attractive in that, for the same expected value as stock grants, they can provide the principal leverage to motivate an executive to undertake more extensive plan evaluation. In short, stock options encourage hard work. However, stock options also bias an executive's decision criteria away from first-best. Our analysis establishes stock options are the preferred form of equity compensation if the exercise price is freely chosen, but also shows that 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.

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."[1] 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.

The purpose of this paper is to contrast the use of two forms of equity-based compensation in executive compensation packages, restricted stock grants and stock options, and to explore the potential link between the use of options and the performance of firms. To do so, we adopt the standard approach of principal-agent theory.[2] However, we diverge from the typical model in

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[1] Friday June 28, 2002, page B1.

[2] Although standard, the simple principal-agent approach has recently been challenged by Bertrand and Mullainathan (2000, 2001), who also find support for a "skimming" view of executive compensation, with executives manipulating the pay process itself.

that we cast the executive's role as two-fold, involving an effort choice and a decision criterion choice. In our setting, option-based compensation moves effort toward first-best, but also distorts executive decision-making, increasing the probability of adopting new uncertain plans above first-best. Thus, in contrast to the common advice for managers to "work smart, not hard," we find that stock options encourage a "work hard, not smart" approach among executives.

The paper is organized as follows. To illustrate the potential effects of stock grants versus stock options on executives' actions, 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] Section 2 considers how the substitution between stock grants and stock options influences the behavior of executives in the context of the plan-selection model.

A key finding developed in Section 2 is that, if the firm is unconstrained in its choice of the exercise price on options awarded to an executive, an equity-compensation package consisting only of options is the preferred form. Specifically, being able to choose the optimal exercise price allows the principal to limit the decision-distortion consequences associated with options while taking advantage of the tendency of options to encourage effort through leverage, thus making options preferred to the granting of restricted stock. There are two important features of

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[3] This view follows Barron and Waddell (2003) and, in particular, Murphy (1999) who 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). Other papers that have considered the association between investment behavior and executive compensation include: Lambert (1986), who analyzes risk-averse executives' plan choices showing that the executive and principal will not always agree regarding which plan is best but do not consider the methods of compensation that we consider here; Campbell, Chan and Marino (1989), who suggest a pre-commitment of performance level by managers to remedy adverse selection problems that arise when managers have private information about their own ability and about the value of plans; Smith and Watts (1992), who undertake an empirical explanation of corporate financing, dividend and compensation policies; Hirshliefer and Suh (1992), who analyze the effects of desirable risky growth opportunities and effective monitoring institutions; and Bizjak, Brickley and Coles (1993), who analyze the impact of growth opportunities on the method of CEO compensation.

our theory. First, unlike the findings of Hall and Murphy (2000), risk aversion on the part of executives is not necessary for a finite optimal exercise value in our model.[4] The reason for this is that we have expanded the nature of the executive's problem to a project-selection setting in which options distort executive decision making. Second, we identify a "knife-edge" type result, with the optimal equity-based compensation package switching from all stock options to almost all stock grants if the exercise price were set above a critical level.

It is important to note at the outset that our focus is on stock grant versus option compensation in lieu of a more general analysis of the optimal compensation package.[5] Our rationale for doing so is threefold: the observed importance of equity-based compensation in the compensation packages of top executives;[6] a desire to highlight the key differences between these two types of equity-based awards that are often overlooked in principal agent models of executive compensation; and the perception in the popular press that option compensation has in part contributed to executives making decisions that have lead to substantial losses of shareholder wealth.[7]

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[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." They go on to indicate that "The absurdity of this result underscores the need to introduce managerial risk aversion into any analysis of executive stock option valuations and incentives" (p.213).

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

[6] See, for instance, Yermack (1995), Hall and Liebman (1998), Core and Guay (1999), Murphy (1999), and Barron and Waddell (2003).

[7] 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*. "Now, there's nothing intrinsically wrong with stock options; they can motivate employees by granting them a stake in their company's success. What is problematic 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. According to the Federal Reserve, if stock options had been counted from 1995 to 2000, Fortune 500 companies would have seen their annual profit margins drop from 12 percent to 9.4 percent. Among some high flyers the deflation would have been larger still: Counting stock options, Cisco Systems' profits in 2000 would have been 40 percent lower and Lucent Technologies' 32 percent lower." In the following analysis, it is important to recognize that we consider the role of options granted to the top five executives in the company. Such options are public knowledge to the investment community, and thus we do not focus on the cost-accounting feature of options mentioned in the quote, for the public can discern the

Section 3 examines the evidence on the use of equity-based compensation among top executives. We find the use of options rather than restricted stock widespread, yet there remain instances when the compensation packages of top executives include restricted stock. We also find evidence across top-executive ranks that confirms Hall and Murphy's (2000) observation that the "exercise price is nearly always set equal to the current stock price" (p. 209). This leads us to explore the optimal use of restricted stock grants when firms follow a simple rule of thumb in setting the exercise price equal to the grant-date market price (i.e., "at the money"). Through simulations, we 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 set "too high" from an incentive stand point.[8] The restricted stock component of 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. In particular, we identify variables that we argue increase the likelihood that an at-the-money exercise price is higher than optimal for the alignment of incentives, and thus lead to a reduced use of options as a proportion of an executive's equity-based compensation. Our findings are largely consistent with the model's predictions.

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 substituting options for restricted induces executives to be more likely to choose an uncertain plan that is either better or worse than the status quo. This suggests that, other things equal,

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"extra" expected cost of such options to the firm. Instead, we focus on two other incentive-roles that options play, namely a positive one of encouraging effort and a negative one of inducing top executives to take unwarranted risks.

[8] Note that, unlike Hall and Murphy (2000), in this section our focus is not on why an exercise price is set at the money, but rather the implications of such a rule on the optimal use of restricted stock grants versus options.

returns should be more extreme when compensation is weighted toward options. We do find that an increase in the option proportion of total compensation among top executives at a firm increases the likelihood the firm's subsequent three-year return is in the extremes (top or bottom twenty percent of average returns). Section 6 contains concluding remarks and potential extensions.

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

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 proposed plans for the firm. For simplicity, we assume that each executive evaluates a single proposed plan and that the plan is one of only two types; good or bad. The executive either adopts the plan or remains with the status quo. If an executive in position r adopts a good plan, the gross value of the plan after T periods is assumed to be drawn from a distribution with density function h_r^G, expected value V_r^G and standard error σ_r^G. Let h_r^B and V_r^B represent the density function and expected value, respectively, of a bad plan and let h_r^o and represent the density function and expected value of the status quo "plan." The corresponding standard errors are, likewise, σ_r^B and σ_r^o.

We assume 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, while the bad plan's expected value is below the status quo.[9] Let α_r denote the exogenous and known probability that the plan to be evaluated by executive *r* is good.

If the objective is to maximize the expected value of the plan *T* periods from now, an executive can err in plan selection in one of two ways. The executive can reject a proposed plan in favor of the status quo plan when the proposed plan is actually good and should have been adopted. Or, the executive can adopt a proposed plan over the status quo when the proposed plan is bad and should have been rejected. Adopting the terminology of Sah and Stiglitz (1988), the rejection of a good plan is a Type I error and the adoption of a bad plan is a Type II error. Note that a natural way of characterizing more senior positions is to have these mistakes be more costly for executives in these positions. As such, all else equal, we think of more senior positions as positions with a greater expected loss to the firm from rejecting a good plan, $V_r^G - V_r^o$, or from accepting a bad plan, $V_r^o - V_r^B$.

1.2. Executives' decision variables

In evaluating a plan, we assume that an executive receives an imperfect signal, *s*, of the plan's underlying value to the firm. For an executive in position of rank *r*, if the plan is good the signal is drawn from a normal distribution with cumulative density function $F_G(s)$, mean μ_G and precision P_r.[10] If the plan is bad, the signal is drawn from normal distribution $F_B(s)$ with mean μ_B and precision P_r. We assume that $F_G(s)$ first-order stochastically dominates $F_B(s)$, such that good plans tend to generate higher signals on average, or $\mu_G > \mu_B$. The two-dimensional action of the executive is introduced with respect to this signal generating process.

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[9] 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.
[10] For discussion purposes we talk of signal precision and not signal variance, while it remains true that precision is simply the reciprocal of the variance of the signal.

Specifically, an executive who evaluates a proposed plan can affect the precision of the signal of plan type by investing costly effort into the evaluation of the plan. To capture this we let $P_r = f(e_r, \upsilon)$, with $\partial f / \partial e_r > 0$ and $\partial^2 f / \partial e_r^2 \leq 0$, where e_r denotes the choice of evaluation effort for the executive assigned to position of rank *r* and υ is a parameter affecting the precision of the signal for a given level of effort. Given this, we amend our notation to account for this effort choice; if the plan is good the signal is drawn from $F_G(e_r, s)$, if the plan is bad the signal is drawn from $F_B(e_r, s)$.

Once a signal on a proposed plan is received, the executive must determine whether to accept or reject the plan based on the information revealed. This decision to accept or reject is captured by the executive's choice of reservation signal, $\hat{s}_r$. If the signal obtained for the proposed plan is above the chosen reservation signal, $\hat{s}_r$, 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.[11] For a given evaluation effort, e_r, and reservation signal, $\hat{s}_r$, the executive therefore rejects a proposed plan that is good with $F_G(e_r, \hat{s}_r)$. 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.

1.3. The principal's objective and 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) $$E[V_r\ (e_r, \hat{s}_r)] = V_r^* - F_G(e_r, \hat{s}_r)k_r^I - (1 - F_B(e_r, \hat{s}_r))k_r^{II} \quad ,$$

[11] 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).

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 ($V_r^* = \alpha_r V_r^G + (1-\alpha)V_r^o$) is reduced by losses associated with Type I errors (L_r^I) and Type II errors (L_r^{II}). 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.

Assuming independence in plan returns across executives, the principal's expected future gross value from the *n* plans separately evaluated by the *n* executives can be expressed as:

$$(2) \qquad V(\boldsymbol{e},\hat{\boldsymbol{s}}) = \sum\nolimits_{r=1}^{n} \mathrm{E}[V_r\ (e_r, \hat{s}_r)] \quad ,$$

where $\boldsymbol{e} \in \{e_1,\ldots,e_n\}$ is a vector of efforts and $\hat{\boldsymbol{s}} \in \{\hat{\boldsymbol{s}}_1, \ldots, \hat{\boldsymbol{s}}_n\}$ is a vector of reservation signals across the *n* executives. The first-best evaluation effort and reservation signal for an executive in position r, $r = 1, \ldots, n$, maximize the shareholders' expected value of the plan, as defined by Eq. (2), net of the executive's effort costs. Given a simple quadratic cost function for the executive's effort, $c(e_r) = e_r^2/2$, the first-best e_r and $\hat{s}_r$ for the executive in position *r* satisfy the problem:

$$(3) \qquad \max_{e_r,\hat{s}_r} \quad \rho \mathrm{E}[V_r\ (e_r,\hat{s}_r)] - e_r^2/2 \quad .$$

where the discount factor $\rho \in [0,1]$ converts the gross future value to be received in *T* periods into current values.

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

$$(4) \qquad \hat{s}_r^* = \frac{-\ln\left(\Phi_r\right)}{P_r(e_r)\ (\mu_G - \mu_B)} + \frac{\mu_G + \mu_B}{2} \quad ,$$

where

(5) $$\Phi_r = k_r^I / k_r^{II}$$

denotes the ratio of expected losses from Type I and Type II errors made by an executive in the position of rank *r*. Note that if symmetry exists in the expected gain and loss from plan selection, such that $k_r^I \equiv \alpha_r (V_r^G - V_r^o) = (1-\alpha_r)(V_r^o - V_r^B) \equiv k_r^{II}$, then the decision criterion is independent of the specific level of evaluation effort.

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

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

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.

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 stocks 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.[12] 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, that is, *T* periods. 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:

$$C_r = \begin{cases} \delta_r + \rho(\beta_r^R V + \beta_r^O (V - V^E)) & \text{if } 0 < V^E \leq V \\ \delta_r + \rho(\beta_r^R V) & \text{if } V < V^E \end{cases} \quad . \tag{7}$$

In Eq. (7), 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 acquires in *T* periods through stock holdings and stock options, respectively. We adopt a common discount factor of $\rho < 1$. Eq. (7) 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

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

option grant and is set before the executive chooses 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 (7). To do so, we first divide the value of the firm into two components, the value arising from the decisions of the executive in position *r*, V_r , and the value arising from the decisions of the other *n*-1 executives employed at the firm in positions –*r*, V_{-r}.

Let $g_{-r}(V_{-r})$ denote the density functions for the value of the sum of the other *n*-1 executives' plans. Assume the realized value for the decision made by each executive has common lower and upper bounds of zero and $\overline{V}$, respectively. Then, from (1) and (2), the expected future value of the firm is given by:

$$(8) \qquad \mathrm{E}[V] = \int_0^{(n-1)\overline{V}} y g_{-r}(y)\,dy + \alpha_r \int_0^{\overline{V}} x h_r^G(x)\,dx + (1-\alpha_r)\int_0^{\overline{V}} x h_r^o(x)\,dx - F_G k_r^I - (1-F_B)k_r^{II} \quad ,$$

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

$$(9) \qquad k_r^I = \alpha_r \int_0^{\overline{V}} x\,(h_r^G(x) - h_r^o(x))\,dx$$

and

$$(10) \qquad k_r^{II} = (1-\alpha_r)\int_0^{\overline{V}} x\,(h_r^o(x) - h_r^B(x))\,dx \quad .$$

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.

In contrast, the option holder is interested in the expected value of the firm as it relates to an exogenous exercise value, V^E.[13] 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,

$$\mathrm{E}[V^O] = E[\, V - V^E \,|\, V \geq V^E\,]\Pr(V \geq V^E) \quad . \tag{11}$$

To make the comparison between equity and options more transparent, 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, let the loss from a Type I error for an option holder be denoted by $\phi_r^I L_r^I$ and the loss from a Type II error for an option holder be denoted by $\phi_r^{II} L_r^{II}$. 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 $\lim_{V^E \to 0} \mathrm{E}(V^O) = \mathrm{E}(V)$.

2.1. Effort and plan selection of risk-neutral agents

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 (7). That is, the executive's problem is:

$$\max_{e_r, \hat{s}_r} \quad \delta_r + \rho(\beta_r^R \mathrm{E}[V] + \beta_r^O \mathrm{E}[V^O]) - c(e_r) \quad , \tag{12}$$

where (8) and (11) define $\mathrm{E}(V)$ and $\mathrm{E}(V^O)$, respectively. The first-order conditions for the executive's reservation signal and effort are:

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[13] 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).

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

and

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

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

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

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 options versus stock and the ratio of losses from Type II error for options versus stock, 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. From the executive's maximization problem, assuming the existence of unique solutions, we have the following implicit solutions for the optimal evaluation effort and signal choices of the executive assigned to position *r*:

(16) $$e_r^{**} = g_r(\;\beta_r^R,\;\beta_r^O,\;V^E, k_r^I, k_r^{II}, \phi_r^I, \phi_r^{II}, \rho)$$

and

(17) $$\hat{s}_r^{**} = j_r(\;\beta_r^R,\;\beta_r^O,\;V^E, k_r^I,\; k_r^{II}, \phi_r^I, \phi_r^{II}, \rho) \quad .$$

2.2 The case of a single risk-neutral agent

The complexity of the expressions underlying the expected value of compensation in the form of options makes it difficult to clearly see the positive and negative roles that options can play in compensation. To highlight these two distinct roles, we simplify by considering a single agent. Setting $n = 1$ and omitting the subscript indicating an executive in position r, we can rewrite the expected value of equity shares as:

$$\mathrm{E}(V) = \alpha V^G + (1-\alpha)V^o - F_G k^I - (1-F_B)k^{II} \quad . \tag{18}$$

Recall that $k^I = \alpha L^I$, $k^{II} = (1-\alpha)L^{II}$, $L^I = V^G - V^o$ and $L^{II} = V^o - V^B$. When $n = 1$, the expected value of options is:

$$\begin{aligned}\mathrm{E}[V^O] = {} & \alpha \int_{V^E}^{\bar{V}} (x - V^E)h^G(x)dx + (1-\alpha)\int_{V^E}^{\bar{V}} (x - V^E)h^o(x)dx \\ & - F_G \phi^I k^I - (1-F_B)\phi^{II} k^{II}\end{aligned} \quad , \tag{19}$$

where the expected losses from Type I and Type II errors for a holder of options are:

$$\phi^I k^I = \alpha \int_{V^E}^{\bar{V}} (x - V^E)(h^G(x) - h^o(x))dx \tag{20}$$

and

$$\phi^{II} k^{II} = (1-\alpha)\int_{V^E}^{\bar{V}} (x - V^E)(h^o(x) - h^B(x))\,dx \quad . \tag{21}$$

Combining (18) through (21), the agent's expected compensation is given by:

$$\begin{aligned}\mathrm{E}[C] = {} & \delta + \rho\beta^R(\alpha V^G + (1-\alpha)V^o) \\ & + \rho\beta^O(\alpha \int_{V^E}^{\bar{V}} (x - V^E)h^G(x)dx + (1-\alpha)\int_{V^E}^{\bar{V}} (x - V^E)h^o(x)dx) \\ & - \rho\beta^R(F_G k^I + (1-F_B)k^{II}) - \rho\beta^O\left(F_G\phi^I k^I + (1-F_B)\phi^{II}k^{II}\right) \quad .\end{aligned} \tag{22}$$

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:

$$(23) \qquad \max_{\delta,\ \beta^R, \beta^O, V^E,\ e,\ \hat{s}} \quad \rho \mathrm{E}[V] - E[C] \quad ,$$

subject to the agent's optimal choices of reservation signal and effort (the incentive compatibility constraints (13) and (14)), the agent's rationality constraint ($E(C) - e^2 / 2 = u$), and non-negativity constraints on δ, β^R, β^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

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 $\beta^O > 0$, 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.[14]

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 coincident with increasing the exercise value from zero.

2.4 Options distort intentions

Our twofold characterization of the executive's problem reveals that the benefit from substituting restricted stock for options, namely the encouragement of effort through leveraging, is tempered by a negative effect on the chosen reservation signal. This negative effect arises due to the fact that 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

[14] While our focus is on the incentive structure of top-executive compensation, the model need not be limited to considering the highest levels of organization. For instance, one might expect broad-based stock options that are awarded to lower-level employees to simply act to extract additional effort. As lower-level employees may only contribute effort, with decisions being made by supervisors, the downside to options would be discounted in contracting with such employees. 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.

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. 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 (approving a bad plan).

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 (4), (5), (13), and (15), that the first best reservation signal is chosen if the executive faces the same ratio of losses as the principal. That is, if $\Phi = \Phi^E$, or

$$\frac{\beta^R + \phi^I \beta^O}{\beta^R + \phi^{II} \beta^O} = 1 \quad . \tag{24}$$

For a positive V^E, $\phi^I > \phi^{II}$ and Eq. (24) does not hold; for an option recipient (i.e. for $\beta^O > 0$), a Type II error is now relatively less important than it is for the principal or stock recipient.[15] Comparing (4) and (13), this asymmetry in losses across types of compensation means that $\hat{s}^{**} < \hat{s}^*$.

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

[15] Supplement A provides the specific assumptions that support this statement.

obtained from simulations of the model assuming the principal optimally chooses the mix of stock options and stock at each exercise value.[16]

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 illustrated in Panel D. However, as Panel B indicates, an increasing exercise value introduces distortions in the reservation signal away from first-best levels ($\hat{s} = 0$), 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. The evidence on optimal 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 ($\delta = 0$) and the level of restricted stock grants is zero ($\beta^R = 0$), such that all compensation is in the form of options.

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[16] 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.

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.[17] Limiting our attention to executives who receive equity compensation yields a sample of 55,763 executive-year observations, reflecting the compensation of the top 5 executives at, on average, 1,478 firms each year for this 9-year period.

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.

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[17] 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.

3.2 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.[18] 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.

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 could 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

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[18] 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.

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.[19] Murphy and Hall (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 following 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.

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:

$$V^C = \rho E[V(e^*, \hat{s}^*)] - E[C(e^*)] \quad . \tag{25}$$

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 (25). Thus, our benchmark simulation can be interpreted as one for which it is optimal for the principal to follow the simple

[19] 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.

rule of thumb of setting the exercise value equal to the grant-date market value of the firm.[20] 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^G and a decrease in V^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^G and V^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^o constant, it is clear that these changes increase to the same degree the underlying costs to the stock holder of a Type I error ($V^G - V^o$) and a Type II error ($V^o - V^B$). 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.

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

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*. 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.[21] 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 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^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

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[21] That is, we assume $\partial P / \partial \upsilon < 0$ and $\partial P^2 / \partial e \partial \upsilon > 0$. In our simulations, we adopt the following specific form for the signal precision function: $P = 1/(\gamma + (\upsilon/(1+\lambda)e))$. 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.

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 expenditure 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 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:[22]

> **Hypothesis 4:** If dividends are paid, 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 current dividends of the firm. We assume that if dividends are paid, this is associated with a perceived increased likelihood of future dividend payments. Our measure for future dividend policy is thus a variable that equals one if the firm currently pays dividends, and zero otherwise.

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 suggested in Table 1, the option-proportion of equity compensation is frequently at the upper or lower bounds. Recognizing these issues, we adopt the

[22] Our view, that a reduced reliance on dividends helps explain an increased use of options, contrasts with Lambert, et al (1989) and, more recently, Fenn and Liang (2001), who reverse the causation and suggest that the use of stock options may help explain a reduced reliance on dividends.

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.[23]

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 ten 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.

Other control variables include in our empirical analysis are a market return volatility measure, a set of dummy variables indicating the industry of the firm, and a time trend variable. 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.

Table 3 reports the results of empirical tests of hypotheses 1 through 4. Columns 1 and 2 provide these results for a pooled sample of executives and Column 3 provides results of the

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[23] Columns 1, 2 and 4 of Table 3 report the results of Probit models that accommodate our potential econometric problem and answer this question. For this estimation procedure, we duplicate the dataset and create a binary variable equal to one for the original dataset and zero for the duplicate. We then weight each "original" observation by the observed proportion of the executive's total equity compensation that was awarded as stock options and weight each "duplicate" observation with one minus the respective 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 for the entire sample reported in columns 1, 2 and 4 are robust to using Logit-transformed proportions as the dependent variable. Results are also robust to using simple proportions, so concern for the effect of not accounting for the boundedness and lumpiness of the dependent variable appears to be unwarranted. Finally, it should be noted that the use of a Heckman specification to control for the use of equity-based compensation is not justified for our data by a likelihood ratio test.

same underlying data controlling for executive-firm fixed effects. The earlier discussion of executives at firms specifically named in the June 28, 2002, *Wall Street Journal* receiving significantly more options is based on the results reported in Column 2. Controls for time trend, for the firm's average rate of return and for return volatility are each found to be significant in determining the use of stock options.

4.3. Results

In Table 3 we report evidence 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 (Hypothesis 1). 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 of our full sample (Column 1 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 1.6 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.[24] 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

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[24] 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.

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 executive-specific effects also indicates an increase in the proportion of equity compensation with a move to a higher rank within the firm.

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, while known to 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 7.1 percent more 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, the fixed-effect result of Column 3 indicates that in terms of the breakdown of equity into stock options and restricted stock, there is no compelling evidence that firms adjust the mix of equity awards in responds to changes in size.

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 3.6 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 change in the use of options over restricted stock when a given firm becomes more or less research intensive. Thus, our sample suggests that the relationship identified is properly thought of as cross-sectional.[25]

[25] 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 a given year are 7.9 percent less likely to award a given equity-compensation dollar as stock options. However, as with the research and development variable, the result for the pooled sample does not carry over to the fixed effects model 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 equation with the addition of our 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 do 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 4.5 percent.[26]

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 1.8 rather than 4.5 percent. 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.

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[26] 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.

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 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 reports 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.[27]

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. 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. 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 identifies a tradeoff implicit in equity compensation that takes the form of stock grants or stock options. Facing a plan of unknown value to the firm, for an exogenously determined signal precision, stock recipients set approval

[27] 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.

standards closer to those preferred by shareholders in making decisions to adopt or reject proposed plans. Option recipients, on the other hand, are too willing to take on risky new plans as they face less downside risk than do shareholders. This “option distortion” in setting the criteria for adopting new plans can be costly to shareholders.

However, there is a benefit to compensating executives with stock options in that, by leveraging a given expected compensation in the form of stock into a larger number of stock options, option compensation provides greater incentive for the agent to determine the true value of the plan being proposed. When the principal’s choice of the exercise price is unconstrained, this leverage value outweighs the costs associated with option distortion, and stock-option awards lead to more efficient outcomes than stock grants of equal expected value. However, firms may find it optimal to award some equity-based compensation in the form of stock grants if an at-the-money rule for setting exercise values constrains the principal’s choice.

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 set “too high,” such that a gain to replacing stock options with restricted stock is more likely. The evidence appears to support this view, in that the likelihood of equity compensation in the form of options is decreasing in an executive’s rank, firm size, and dividend policy, while increasing in research intensity. Consistent with this discussion, we also find evidence of a systematic increase in the use of options conditional on options not being awarded at the money.

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' compensations include a larger proportion of stock options supports this view. 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 to evaluate, and we plan on adding features such as this to future analysis. Another important feature of this future research will be to incorporate equity and non-equity forms of compensation in a more general theory of executive compensation. This more general model would incorporate the "skimming" issues identified by Bertrand and Mullainathan (2000, 2001) and equity considerations suggested by Bolton and Ockenfels (2000).

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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.

				For those with equity-based compensation, proportional breakdown of equity into stock options and restricted stock				
Year	Percent of executives with some equity-based compensation	Number of (top-5) executives in full sample	Number of firms in full sample	Percent with no options	Percent with both options and restricted stock	Percent with only options	Number of top 5 executives with equity-based compensation	Number of firms with equity-based compensation
1992	63.52%	5,724	1,396	9.08%	16.89%	74.04%	3,636	994
1993	70.96%	7,563	1,634	7.06%	16.96%	75.98%	5,367	1,333
1994	73.02%	8,063	1,685	5.71%	18.16%	76.14%	5,888	1,404
1995	73.42%	8,313	1,741	5.96%	19.79%	74.24%	6,103	1,454
1996	77.68%	8,876	1,886	5.89%	19.26%	74.85%	6,895	1,653
1997	78.34%	9,158	1,942	5.00%	19.19%	75.80%	7,174	1,709
1998	81.02%	9,197	1,927	4.76%	20.19%	75.05%	7,451	1,750
1999	82.23%	8,761	1,798	3.41%	19.73%	76.86%	7,204	1,649
2000	84.58%	7,147	1,456	3.76%	21.99%	74.26%	6,045	1,358
Overall	76.60%	72,802	15,465	5.38%	19.30%	75.32%	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	Thousands of dollars	Book value of physical plant, inventories, and investments in unconsolidated subsidiaries in billions 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 pays dividends	0, 1	Indicator that firm currently paid dividend in 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
Firm industry indicators	0, 1	Indicator variables: 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. Reported coefficients for Column (3) are estimates of a fixed-effect model for an unbalanced panel of executives. Absolute value 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 that receive equity compensation			Executives that 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 [a]	-0.017	-0.017	-0.056	-0.010
	(3.01)***	(3.03)***	(8.38)***	(2.67)***
Log of firm book value of assets	-0.013	-0.014	-0.004	-0.012
	(11.03)***	(11.14)***	(1.26)	(15.60)***
Firm ratio of research and development	0.393	0.394	0.014	0.189
to book value of assets	(7.87)***	(7.88)***	(1.12)	(6.06)***
Firm pays dividends	-0.064	-0.064	0.012	-0.041
	(14.71)***	(14.69)***	(1.48)	(14.35)***
Firm prior three-year return	0.012	0.010	-0.015	0.012
	(2.06)**	(1.95)*	(3.24)***	(3.32)***
Indicator that three year return	.0094	0.009	0.005	0.003
variable missing [c]	(1.87)*	(1.84)*	(0.79)	(0.93)
S&P 500 60-month return volatility	0.324	0.318	0.341	0.333
	(2.07)**	(2.04)**	(2.26)**	(3.11)***
Trend (1992 = 1)	0.005	0.005	0.006	0.000
	(8.11)***	(8.07)***	(8.81)***	(1.06)
Executive employed at firm listed		0.070		
in the *Wall Street Journal* [b]		(4.03)***		
Executive received stock options				0.036
in the money				(6.02)***
Executive received stock options				0.015
out of the money				(2.31)**
Industry indicator variables included	Yes	Yes	No	Yes
Constant			0.884	
			(34.70)***	
Observations	55,763	55,763		52,761
Observations / number of unique firm-executive combinations			55,763 / 18,811	
	Wald $\chi 2(29)$ = 1435.55	Wald $\chi 2(29)$ = 1154.17	F(8, 36,944) = 23.55	Wald $\chi 2(30)$ = 1216.89

[a] Results are robust to five indicator variables representing the rank order of executives within each firm according to total compensation.
[b] 28 June 2002, page B1.
[c] Where missing, we substitute the average three-year return from the sample of non-missing observations.
* 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

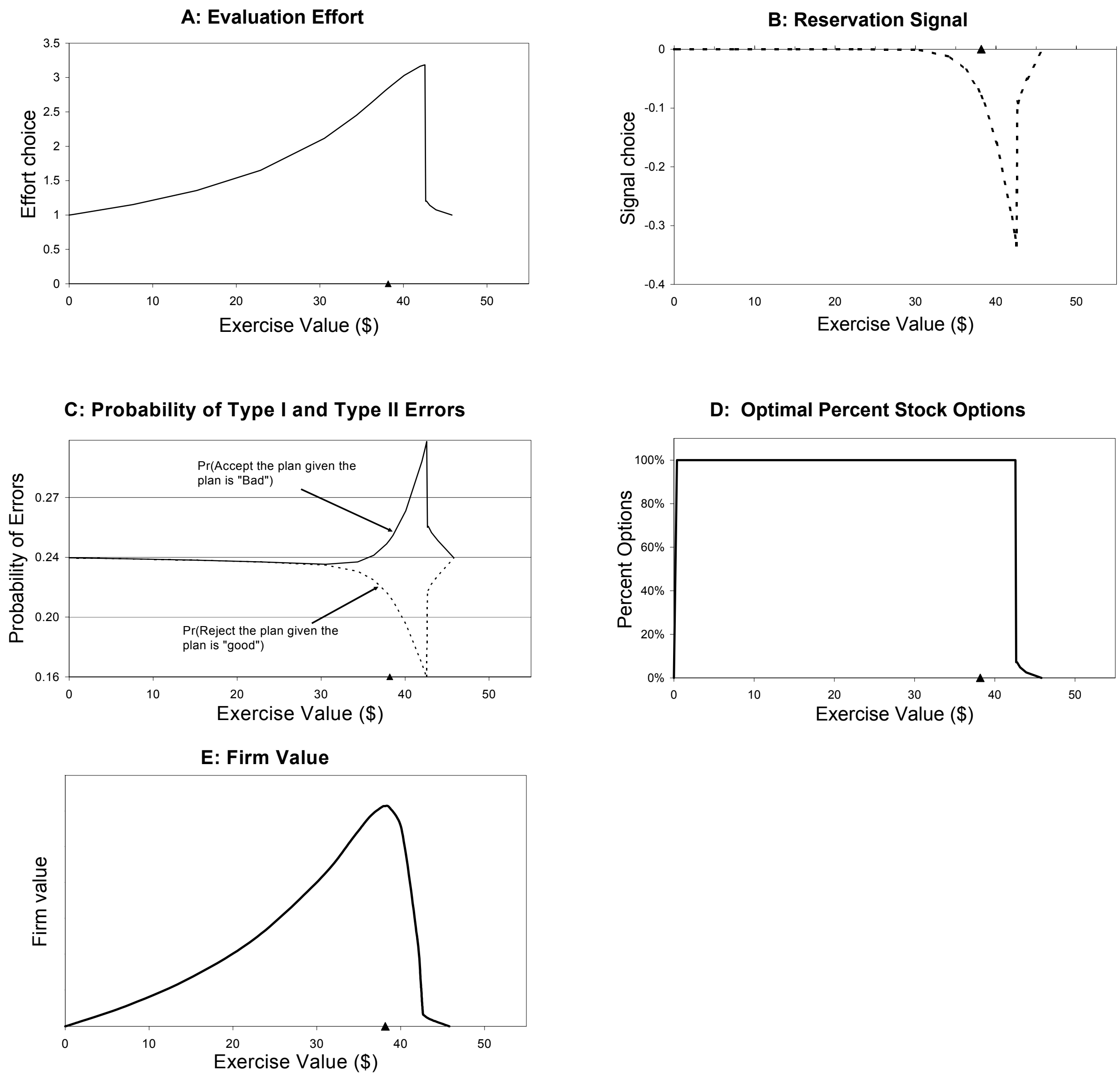
Reported coefficients are from the estimation of a multinomial Logit model of a firm's future rate of return (including dividends) over the subsequent three-year period that takes one of three values: top 20% of returns, middle 60% of returns, and bottom 20% of returns. Reported coefficients for all 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 interacting 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 seven-year period from 1995 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 (8.91)***	1.220 (7.70)***	.936 (6.03)***	0.419 (2.50)***
Log of firm book value of assets			-0.248 (8.73)***	-0.067 (2.04)**
Firm ratio of research and development to book value of assets			-0.719 (0.91)	2.741 (3.92)***
Firm pays dividends			-.415 (4.40)***	-.826 (8.11)***
Firm prior three-year return			.449 (3.76)***	-.091 (0.68)
S&P 500 60-month return volatility			7.928 (1.30)	-10.114 (1.45)
Trend (1992 = 1)			.011 (0.37)	-.036 (1.10)
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 (25.62)***	-1.784 (28.26)***	.293 (0.74)	-.085 (0.22)
Observations	8,537		8,537	
	Wald $\chi2(10) = 165.6$		Wald $\chi2(64) = 5,163.5$	

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

Figure 1

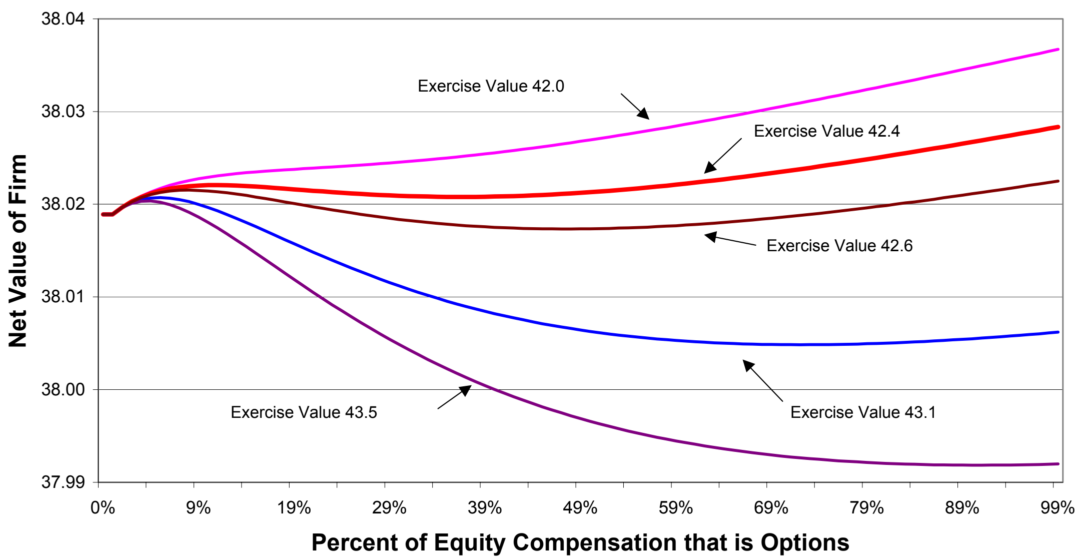
Effects of Changes in the Exercise Value on Effort (A), Reservation Signal (B), Probability of Type I and Type II Errors (C), Optimal Percent of Compensation that is Options (D), and Net Firm Value (E)



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.

"Hard work versus good intentions: 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:

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

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:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

where

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

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

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

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

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

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

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

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

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

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

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

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

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:

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

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,

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

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

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

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 ($\beta^R > 0$).

“Hard work versus good intentions: 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
$\sqrt{\gamma + \upsilon/(1+\lambda e_r)}$	Function linking standard error of signal distribution to agent *r*’s effort.	
γ	Parameter in signal error function.	1
υ	Parameter in signal error function.	1
λ	Parameter in signal error function.	3
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
$\Phi_r^E=\dfrac{(\beta_r^R+\phi_r^I\beta_r^O)k_r^I}{(\beta_r^R+\phi_r^{II}\beta_r^O)k_r^{II}}$	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