Executive rank, pay and project selection[☆]

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Abstract

This paper extends the literature on executive compensation by developing and testing a principal-agent model in the context of project selection. The model's focus on executive project selection decisions highlights the multidimensional nature of executive choices that affect the value of the firm. An executive not only makes an effort choice that determines the quality of information on which to base a decision but also sets the decision criteria for selecting projects. A project selection framework is also shown to introduce endogenous uncertainty into compensation that can influence the executive's effort choice. Using an extensive data set, our empirical work supports the main hypotheses of the model, including the significance of executive rank in determining the extent of use of incentive pay in general and equity-based incentive pay in particular.
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1. Introduction

The literature on the pay–performance characteristics of chief executive officer (CEO) compensation is extensive.[1] Recently, a number of papers have considered the use of different types of performance measures in CEO contracts. For instance, Bushman et al. (1996) consider the explicit use of individual performance evaluation in CEOs' annual incentive plans for a sample of 396 firms over the six-year period from 1990 to 1995. Ittner et al. (1997) explore the use of financial versus nonfinancial performance measures in CEO bonus contracts for a sample of 317 firms during the years 1993 and 1994. Core and Guay (1999) consider the determinants of equity incentives in CEO compensation for a sample of 5,352 CEO-year observations during the 1992 to 1997 period. Kole (1997) contributes to this literature with an empirical analysis of firms' compensation plans for the 1980 Fortune 500 firms through which she identifies factors that influence the *availability* of different types of equity-authorizing compensation plans at 371 of that year's Fortune 500 firms.[2]

While the above analyses have advanced understanding of managerial compensation contracts, a number of issues, both theoretical and empirical, remain that we seek to address in this paper. On the theoretical side, our aim is to expand the analysis of CEO contracts suggested by Banker and Datar (1989) and Sloan (1993) to account for differences in the use of incentive pay in general, and equity-based compensation in particular, across top executives of different positions. To do so, we develop a theoretical framework for our empirical analysis that adopts a view similar to Lambert (1986) concerning the actions executives take to enhance the value of the firm.

In the standard principal-agent approach, each executive's actions are summarized by a single variable, effort. Increases in effort improve firm performance, but at a cost to the executive. Assuming effort is not directly observable, the optimal compensation package links payments to various signals of the executive's level of effort, with risk aversion on the part of the executive limiting the extent to which compensation can be tied to imperfect signals. This approach has proven useful in a wide variety of applications even though it adopts a simple characterization of the actions taken by the executive as an agent of the firm's shareholders. However, to

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[1] Jensen and Murphy (1990), in their well-cited analysis, find little support for a link between the pay of CEOs and their performance using a Forbes sample of the CEOs of 1,049 firms from 1974 to 1986. More recently, Hall and Liebman (1998) produced contradictory evidence using data on 478 large U.S. companies for the years 1980 to 1994. While Hall and Liebman perceive the importance of alternative components of compensation packages, they do not attempt to explain why packages vary across CEOs and other top executives. Yermack (1995) provides a good review of CEO stock options. Two recent examples of papers that consider various aspects of the pay-performance relationships for executives are Ke et al. (1999) and Aggarwal and Samwick (2003).

[2] For her sample, Kole (1997) demonstrates that "the authority of the board to grant equity [as compensation to executives] can be predicted by the mix of tangible and intangible assets in the firm and, to a lesser extent, by firm size" (p. 103). Also notable is her finding that "the boards of firms that are larger, more diverse, and more research-intensive are more likely to have greater flexibility in contracting" (p. 103).

better understand the potential roles of various types of compensation, we adopt a more explicit description of what an executive does within the firm.

In Section 2, we outline a model in which executives, as agents of shareholders, invest effort to collect information on the value of projects and then make decisions regarding whether to accept or reject these projects. Examples of such projects could include the hiring of an outside subcontractor or a key employee, the acceptance or rejection of a proposed marketing plan, or the choice of a new product line. In this context, the value of the firm is influenced not only by the executive's effort choice that determines the quality of information on which to base a decision, but also by the executive's choice of the decision criteria for selecting projects. In short, executives' actions are multidimensional, and one has to consider the extent to which a particular compensation package encourages costly effort by the executive as well as the potential for the compensation package to distort the executive's decision criteria away from that of the principal.

To keep our analysis simple, we limit our discussion throughout the paper to an executive evaluating a single new project. Section 2 focuses on the agent's effort choice in improving the quality of information about potential projects. Even for this simple version of a project selection model, several new features emerge. For instance, increased effort to improve the informativeness of the signal on the quality of a project not only benefits the principal by raising the expected return, but also can benefit the risk-averse agent by reducing the uncertainty of compensation based on the project's return.

The model developed in Section 2 allows us to formalize the relationships between various firm characteristics cited by Kole and others and the use of incentive and equity-based compensation. The model also provides a rationale for additional explanatory variables such as the rank of the executive's position. Section 3 identifies these testable hypotheses regarding the composition of compensation, both with respect to the proportion of compensation that is incentive-based and the proportion of incentive-based compensation that is equity-based.

Section 4 presents the results of tests of the hypotheses developed in Section 3. On the empirical side, the paper contributes to the existing literature in several ways. First, we examine whether Kole's *ex ante* characterization of compensation contracting for 371 Fortune 500 companies in 1980 compares with more recent *actual* forms of compensation adopted by both Fortune 500 and non-Fortune 500 companies. We find that many of the tendencies Kole identified with respect to the potential use of equity-based compensation across firms using data now more than 20 years old are more pronounced when one considers the actual use of equity-based compensation for an extensive sample of annual compensation data for executives from over 1,700 firms each year during the 1992–2000 period.

Second, we document the theory's predictions regarding the roles of such variables as firm size, the level of research and development (R&D), the volatility of equity returns, and executive rank on both the extent of incentive pay and the extent of equity-based incentive pay. One important finding is a systematic increase in the use of incentive pay, and specifically in the use of equity-based compensation, at higher-level positions as predicted. In particular, executives in the top position are 30.3%

more likely to receive a given dollar of compensation tied to various performance measures than those in fifth-ranked positions. Following individual executives within our sample through time with a fixed-effect model confirms that compensation becomes more incentive-based and, further, that incentive pay becomes more equity-based as one moves up in position within the same firm. For example, the fixed-effect results indicate that moving from the bottom rank of our sample to the top rank (within the same firm) increases the predicted proportion of total compensation that is incentive pay by 49.1% and increases the predicted proportion of incentive pay that is equity-based by 70.9%. With the growth in the use of equity through the early 1990s (Hall and Liebman, 1998) and the evidence of this trend continuing through 2000, this analysis is timely and significant in its contribution to the overall understanding of how executives are compensated.

2. A model of project selection

Consider n executive positions at a firm ordered according to rank, $r = 1, \ldots, n$, with more senior positions having a lower r. More senior positions are positions in which more important decisions are made; below we make clear what we mean by more important decisions. Following Lambert (1986), the role of the executive in each of these n positions is to determine whether to accept or reject proposed projects.

2.1. Project characteristics

For simplicity, we assume that each executive evaluates a single project and that the project is one of only two types. A good project has a net present value that exceeds the status quo; a bad project less than that of the status quo.[3] Let V_r^G, V_r^B, and V_r^0 represent the net present values to the risk-neutral owners of the firm (or principal) generated by an executive in position r adopting a good project, adopting a bad project, and maintaining the status quo, respectively, with $V_r^G > V_r^0 > V_r^B$. Let α_r denote the exogenous and known probability that the project to be evaluated by executive r is good.

An executive can err in project selection in one of two ways. The executive can reject a proposed project in favor of the status quo when the proposed project is good. Or, the executive can adopt a proposed project over the status quo when the proposed project is bad. Adopting the terminology of Sah and Stiglitz (1988), the rejection of a good project is a type 1 error and the adoption of a bad project is a type 2 error. In what follows, we focus on differences across executive positions that arise from differences in the costs of types 1 and 2 errors. More senior positions are defined as positions with a greater loss from rejecting a good project ($V_r^G - V_r^0$) and

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[3] For simplicity, we assume that the principal ranks projects 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.

a greater loss from accepting a bad project $(V_r^0 - V_r^B)$. The presumption that mistakes are more costly for executives occupying higher positions within the firm is what we mean when we say that senior positions are positions in which more important decisions are made.

2.2. Executive project evaluation choices

In evaluating a project, we assume that an executive obtains an imperfect signal, s, of the project's underlying value to the firm. For an executive in position of rank r, the signal is drawn from the normal distribution $F_G(s)$ with mean μ_G and precision P_r if the project is good. Precision is the reciprocal of the variance of the signal. If the project is bad, the signal is drawn from the normal distribution $F_B(s)$ with mean μ_B and precision P_r. We assume $F_G(s)$ first-order stochastically dominates $F_B(s)$, such that good projects tend to generate higher signals, or $\mu_G > \mu_B$.

An executive who evaluates a potential project can affect the precision of the signal on project type. Specifically, let $P_r = f(e_r)$, with $f'(e_r) > 0$ and $f''(e_r) \leqslant 0$, where e_r denotes the choice of evaluation effort for the executive assigned to position of rank r. Given this, we amend our notation to account for the potential impact of an executive's evaluation effort on the signal distribution, so that if the project is good the signal is drawn from $F_G(e_r, s)$ and if the project is bad the signal is drawn from $F_B(e_r, s)$. Once a signal on a project is received, the executive assigned to position r must determine whether to accept or reject the proposed project based on the information revealed. This decision to accept or reject depends on the executive's optimal reservation signal, $\hat{s}_r$. If the signal obtained for the proposed project is above the chosen reservation signal, $\hat{s}_r$, the executive adopts the project. If the signal obtained is less than $\hat{s}_r$, the executive rejects the project.

For a given evaluation effort e_r and signal cutoff $\hat{s}_r$, a proposed project that is good is therefore adopted by the executive assigned to position r with probability $1 - F_G(e_r, \hat{s}_r)$ and rejected with probability $F_G(e_r, \hat{s}_r)$. Likewise, a proposed project that is bad is adopted by the executive with probability $1 - F_B(e_r, \hat{s}_r)$ and rejected with probability $F_B(e_r, \hat{s}_r)$. Thus, an increase in $\hat{s}_r$ increases type 1 errors (rejection of a good project) but reduces type 2 errors (adoption of a bad project). We refer to the setting of $\hat{s}_r$, and the resulting likelihood of types 1 and 2 errors, as the executive's choice of the decision criteria for selecting projects.

2.3. The principal's objective

The expected value to the principal of the project selection decision by an executive in position of rank r given a level of effort e_r and reservation signal $\hat{s}_r$ is given by

$$E(V_r(e_r, \hat{s}_r)) = \alpha_r V_r^G + (1 - \alpha_r) V_r^0 - \alpha_r F_G(e_r, \hat{s}_r)(V_r^G - V_r^0)$$

$$- (1 - \alpha_r)(1 - F_B(e_r, \hat{s}_r))(V_r^0 - V_r^B). \tag{1}$$

According to Eq. (1), the first-best outcome (first two terms on the right) is reduced by losses associated with type 1 errors (third term) and by losses due to type 2 errors (fourth term). In the analysis to follow, we assume that the costs of these errors are sufficiently large that it will not be optimal for an executive to adopt the simple rule of not evaluating project proposals and either always rejecting or always accepting.

An important feature of Eq. (1) is the inherent uncertainty in the value of a project even if the executive's effort and reservation signal are known. In general form, we have

$$V_r(e_r, \hat{s}_r) = \mathrm{E}(V_r(e_r, \hat{s}_r)) + w_r^{\mathrm{V}} \varepsilon_r, \tag{2}$$

where $w_r^{\mathrm{V}} \varepsilon_r$ is the difference between the realized value of the executive's chosen project in the position of rank r and its expected value. The term ε_r has mean zero and variance $(\sigma_r^{\mathrm{V}})^2$. We define symmetry in project selection to occur when the expected incremental gain to a good project, $\alpha_r(V_r^{\mathrm{G}} - V_r^0)$, equals the expected incremental loss to a bad project, $(1 - \alpha_r)(V_r^0 - V_r^{\mathrm{B}})$. For the symmetric case, the variance of ε_r depends on the probability of a good project, α_r, and the probabilities of project rejection for each type, $F_{\mathrm{G}}(e_r, \hat{s}_r)$ and $F_{\mathrm{B}}(e_r, \hat{s}_r)$. With symmetry, the scaling term w_r^{V} equals the expected gain to a good project or, equivalently, the expected loss from a bad project.

Assuming independence in project returns across executives, the principal's realized value from the n projects evaluated by the n executives can be expressed as

$$V(\hat{\boldsymbol{s}}, \boldsymbol{e}) = \sum_{r=1}^{n} [\mathrm{E}(V_r(e_r, \hat{s}_r)) + w_r^{\mathrm{V}} \varepsilon_r] + w^{\mathrm{M}} \varepsilon^{\mathrm{M}}, \tag{3}$$

where $\boldsymbol{e} \in \{e_1, ..., e_n\}$ is a vector of efforts and $\hat{\boldsymbol{s}} \in \{\hat{\boldsymbol{s}}_1, ..., \hat{\boldsymbol{s}}_n\}$ is a vector of reservation signals across the n executives, ε^{M} is an exogenous random variable with zero mean and positive variance $(\sigma^{\mathrm{M}})^2$ that reflects fluctuation in the firm's market value independent of project selection, and w^{M} is a scaling factor for market-specific shocks that varies across firms. We assume that ε_r is independent of the exogenous market-performance random component, $\varepsilon^{\mathrm{M}}, r = 1, ..., n$.

2.4. The first-best solution

The first-best evaluation effort for an executive in position r is the level of effort that maximizes the shareholders' expected value of the project net of effort costs, $\mathrm{E}(V_r(e_r, \hat{s}_r)) - c(e_r)$. Given a simple quadratic effort-cost function $c(e_r) = e_r^2/2$, the first-order condition that defines the first-best evaluation effort e_r^* for the executive given the optimal reservation signal $\hat{s}_r^*$ is

$$e_r^* = -\alpha_r \frac{\partial F_{\mathrm{G}}(e_r^*, \hat{s}_r^*)}{\partial e_r}(V_r^{\mathrm{G}} - V_r^0) - (1 - \alpha_r)\frac{\partial(1 - F_{\mathrm{B}}(e_r^*, \hat{s}_r^*))}{\partial e_r}(V_r^0 - V_r^{\mathrm{B}}). \tag{4}$$

The optimal evaluation effort from the shareholders' perspective equates the marginal cost of effort with the marginal benefit arising from the effort's effect on reducing the expected costs of making type 1 and type 2 errors given $\hat{s}_r^*$. The first-best

signal cutoff $\hat{s}_r^*$ is given by

$$\hat{s}_r^* = \frac{-\ln\big((\alpha_r/(1 - \alpha_r))\Phi_r\big)}{P_r(\mu_G - \mu_B)} + \frac{\mu_G + \mu_B}{2}, \tag{5}$$

where

$$\Phi_r = \frac{V_r^G - V_r^0}{V_r^0 - V_r^B} \tag{6}$$

is the ratio of losses from type 1 and type 2 errors made by the executive in the position of rank r. Note that if symmetry exists in the expected gain and loss from project selection, such that $\alpha_r(V_r^G - V_r^0) = (1 - \alpha_r)(V_r^0 - V_r^B)$, then the first-best decision criterion is independent of the specific level of evaluation effort and can be written as $\hat{s}_r^* = (\mu_G + \mu_B)/2$.

2.5. The solution with risk-averse agent and asymmetric information

Eq. (4) defines the first-best evaluation effort of the executive. However, if the principal (the set of shareholders) does not directly observe the effort choice made by a risk-averse executive, then the standard principal-agent trade-off arises. The principal, in linking compensation to imperfect measures of executive effort to encourage such effort, must compensate the executive not only for the disutility of effort but also for the resulting income uncertainty.

Eq. (3) indicates that one measure of the executive's effort is the resulting value of the firm, V. Thus, in the absence of observable evaluation efforts and decision criteria, firm performance can act as a measure of an executive's behavior. However, it is an imperfect measure for three reasons. First, the random outcome of the executive's project reflects the inherent uncertainty in the value of projects being considered as well as project-selection errors made by the executive. Second, firm performance includes the random outcome from the project selection process of the $n - 1$ other executives at the firm. Third, there is the random market component of the firm's valuation that is independent of the project selection choices of all n executives.

There are, however, measures of an executive's choices other than the firm's stock price that, unlike overall market performance, are not influenced by the project selection process of other high-level executives or the random component of the firm's market valuation. Bushman et al. (1996), among others, have noted the importance of individual performance evaluation in CEOs' annual incentive plans, evaluations that are often drawn from accounting data sources. Let the value of such an accounting-performance measure that is specific to the project selection of an executive in position of rank r be given by

$$A_r(e_r, \hat{s}_r) = \mathrm{E}(V_r(e_r, \hat{s}_r)) + w_r^V \varepsilon_r^V + w_r^A \varepsilon_r^A, \tag{7}$$

where A_r is the executive-specific performance measure, ε^A is a normally distributed exogenous noise term with mean zero and strictly positive variance $(\sigma^A)^2$, and w_r^A is a

scaling factor for the noise term. For simplicity, we assume that ε_r^V and ε^A are independent.

Our model now has two imperfect independent measures of the contribution made by each executive. One is the overall performance of the firm as defined by Eq. (3). The second, defined by Eq. (7), can be thought of as one that is extracted from internal data that are correlated with the outcome of the specific project selection of the executive. In comparing Eq. (3) and Eq. (7), three common features emerge. First, the expected value of each performance measure is directly related to the expected value of the executive's project selection, and thus directly related to the executive's effort and decision-criteria choices. Second, the measures have a common error term that reflects the inherently random outcome of project selection. Third, each measure has an additional random component. In the firm-performance measure, the additional random component reflects both the project-selection process of other executives at the firm and random market shocks. In the executive-specific performance measure, the additional random component reflects the lack of perfect correlation between accounting data and the expected value of the project.

We allow the agent's current compensation to take three forms: a base-line salary, a reward or bonus based on the realization of the agent's project-specific performance measure, A_r, and a reward based on the overall performance of the firm in terms of the realized value to the principal, V. Assuming a simple linear compensation rule, the current compensation package for position r takes the form

$$C_r = \delta_r + \beta_r^A A_r + \beta_r^V V, \tag{8}$$

where δ_r is the salary component and the coefficients β_r^A and β_r^V are weights on the executive-specific (accounting) and firm-specific (firm value) measures of performance, respectively. These two coefficients determine the responsiveness of compensation to changes in these performance measures.

Given this compensation rule, we assert the following simple form for the executive's certainty equivalent:

$$CE_r = \delta_r + \beta_r^A E(A_r) + \beta_r^V E(V) - (1/2)e_r^2 - (1/2)\gamma\sigma_r^2, \tag{9}$$

where expected firm value $E(V)$ equals $E(V_r) + \sum_{j \neq r} E(V_j)$, the term $(1/2)e_r^2$ captures the cost of evaluation effort, γ is a measure of the importance of risk in the executive's expected utility, and σ_r^2 captures the endogenous variance in the current compensation of the executive filling position of rank r. This form for the certainty equivalent is common in the principal-agent literature and can be explicitly derived from an exponential utility function, our linear compensation package, and performance measures that are normally distributed. Eq. (9) indicates that the expected payment to the executive (the first three terms) must compensate the agent for costly effort (the fourth term) and risk (the fifth term) given that the agent is risk averse ($\gamma > 0$). The variance in the executive's current compensation,

σ_r^2, is given by

$$\sigma_r^2 = (\beta_r^A + \beta_r^V)^2 (w_r^V \sigma_r^V)^2 + (\beta_r^A)^2 (w_r^A \sigma^A)^2$$

$$+ (\beta_r^V)^2 \left(\sum_{j \neq r} (w_j^V \sigma_j^V)^2 + (w^M \sigma^M)^2 \right). \tag{10}$$

An important aspect of Eq. (10) is that the executive's effort choice can influence the overall variance in compensation as the effort choice affects $(w_r^V \sigma_r^V)^2$. In particular, an increase in executive effort, by reducing the likelihood of costly mistakes, not only increases the expected value of the firm (because $\partial E(V_r(e_r))/\partial e_r > 0$), but also can reduce the variance in executive r's contribution to the value of the firm as it is possible that $\partial(\sigma_r^V)^2/\partial e_r < 0$. This second effect will increase the benefit from effort to any risk-averse agent whenever compensation is linked to the value of the project. This new feature of the agent affecting the extent of risk faced through the effort choice is not apparent in earlier papers on project selection such as Lambert (1986) where the executive's effort decision was framed as a zero/one choice: either perform no effort or perform a fixed, positive level of effort.

Our focus in this section of the paper is on the executive's choice of effort. In order to facilitate this, we assume symmetry in the expected gain and loss from project selection. As noted earlier, symmetry implies that the first-best signal cutoff for the executive's decision to adopt the project is independent of the effort choice. Given symmetry, compensation package (8), and the executive's certainty equivalent (9), the principal's maximization problem can be succinctly stated as follows. Choose each executive's compensation package weights, β_r^A and β_r^V, to maximize the expected value of the firm net of compensation payments made to the n executives, recognizing that changes in the weights β_r^A and β_r^V affect each executive's optimal effort choice (thus satisfying the incentive compatibility constraints). Then adjust the salary component δ_r such that each executive receives a certainty equivalent at least equal to his or her alternative (thus satisfying the individual rationality constraints). The appendix provides a formal statement of the problem.

An important issue heretofore not explicitly dealt with are incentives for increased effort by an executive that are not directly tied to the current compensation package weights β_r^A and β_r^V. For instance, an executive's future career opportunities and thus wealth can be influenced by the recommendations of peers and superiors. If these recommendations are based in part on information obtained through the direct monitoring of the executive, then incentives exist for the executive to perform in addition to the incentives provided by the current compensation package. Alternatively, the executive has incentives to perform if the executive has an equity stake in the firm. To capture these incentive effects that are outside the current compensation package, we introduce a parameter θ_r in the incentive compatibility constraint to denote the marginal impact of a change in project value on the wealth of the executive assigned to position r that is independent of the current compensation package.

3. Hypotheses regarding composition of compensation

We seek to address two key issues using the above theory. The first concerns the determinants of the proportion of total expected compensation that is incentive-based (not salary), where this proportion is defined by

$$\frac{\beta_r^A \mathrm{E}(A_r) + \beta_r^V \mathrm{E}(V)}{\delta_r + \beta_r^A \mathrm{E}(A_r) + \beta_r^V \mathrm{E}(V)}. \tag{11}$$

The second concerns the determinants of the proportion of expected incentive-based compensation that is based on equity, where this proportion is defined by

$$\frac{\beta_r^V \mathrm{E}(V)}{\beta_r^A \mathrm{E}(A_r) + \beta_r^V \mathrm{E}(V)}. \tag{12}$$

As shown in the appendix, from the first-order conditions for the optimal weights and specific functional forms for scaling factors that reflect the presumption that such factors are increasing, concave functions of the expected project or firm value, we obtain the following expression for the ratio of expected compensation from equity to the total expected incentive-based compensation:

$$\frac{\beta_r^V \mathrm{E}(V)}{\beta_r^A \mathrm{E}(A_r) + \beta_r^V \mathrm{E}(V)} = \frac{(\sigma^A)^2}{(\sigma^A)^2 + \sum_{j \neq r}(\mathrm{E}(V_j)/\mathrm{E}(V))(\sigma_j^V)^2 + (\sigma^M)^2}. \tag{13}$$

Eq. (13) is similar to that obtained by Sloan (1993) and Banker and Datar (1989), with three notable exceptions. First, our expression refers not to the ratio of weights on the two performance measures, but to the ratio of expected compensation linked to the two performance measures. This arises from our explicit characterization of the activities of executives in terms of project selection coupled with the presumption that the absolute deviations in these measures from their expected values will be increasing, concave functions of the significance of the projects under consideration. Second, our result is simpler than theirs in that we assume zero covariance in the error terms of the two performance measures. Otherwise, covariance terms would appear as determinants of the weight attached to each measure in determining compensation. Third, our result extends their theoretical analysis by identifying a new source of variation in the firm performance measurement, the $\sum_{j \neq r}(\mathrm{E}(V_j)/\mathrm{E}(V))(\sigma_j^V)^2$ term. For each executive, this component reflects the variation in project selection outcomes of the other $n - 1$ executives.

3.1. Effects of rank

Eq. (11) indicates that factors that increase the optimal weights attached to either the accounting or firm value measures of performance will increase the proportion of compensation that is incentive-based, other things equal. One key factor that differs across positions held by top executives at a firm is the importance of the decisions being made. We have referred to positions that involve more important decision-making as more senior positions or, equivalently, as positions with a lower rank r. In

our model, the measure of the importance of decision-making are that the costs of making mistakes are larger as measured by $(V_r^G - V_r^0)$ and $(V_r^0 - V_r^B)$.

The theory predicts that executives assigned to more senior positions, because of the greater importance associated with the decisions being made, will be provided greater incentives to devote effort to the decision process. We thus have the following hypothesis:

> Hypothesis 1: Executives who are more senior (have a lower r) will have a greater proportion of compensation that is incentive-based.

Note that more important positions are predicted to pay more, not only to compensate the executive for the increased effort sought in such positions but also for the accompanying increased exposure to risk. The empirical analysis uses the total compensation of top executives to determine the ranking of executive positions within a firm, and thus to differentiate positions in terms of the importance of the decisions being made.

From Eq. (13), we note that the ratio of equity-based compensation to total incentive-based compensation is determined by the measures' relative noisiness. Thus, *ceteris paribus*, where there is increased exogenous noise in the executive-specific performance measure [higher $(\sigma_r^A)^2$], the firm optimally compensates the executive by increasing the relative weight placed on firm performance. Likewise, where there is increased noise in the component of firm performance that is exogenous to executive r [increased $\sum_{j \neq r}(\sigma_j^V)^2 + (\sigma^M)^2$], the firm optimally compensates executive r by increasing the relative weight placed on the executive-specific performance measure.

An implication of Eq. (13) is that if, as we have previously assumed, executives in more senior positions evaluate projects of greater significance to the firm, then σ_r^V will be greater for more senior executives. It follows that the variation in firm value reflecting the *other n*–1 executive's project decisions, $\sum_{j \neq r}(\sigma_j^V)^2$, will be less for more senior executives. Thus, for more senior executives, firm value will be a *relatively* less noisy performance measure than the accounting measure according to Eq. (13). We therefore have the following hypothesis:

> Hypothesis 2: Executives who are more senior (have a lower r) will have a higher proportion of incentive-based compensation that is equity-based.

We now consider factors that can affect the composition of compensation across firms instead of across positions within a firm.

3.2. Effects of exogenous variation in market value

The theory suggests the optimal compensation weights will decrease if the noise of the firm value performance measures [as measured by $(\sigma_r^V)^2 + \sum_{j \neq r}(\sigma_j^V)^2 + (\sigma^M)^2$] increases. Such an increase in the noise in the firm performance measure reduces the reliance on this measure in the incentive portion of the optimal compensation package and thus, from Eq. (11), will reduce the proportion of total compensation that is incentive based. One source of noise in the firm measure of performance is the

exogenous variation in the firm's market valuation $(\sigma^M)^2$. We thus have the following hypothesis:

> Hypothesis 3: Executives will have a lower proportion of compensation that is incentive-based if the exogenous variation in market valuation is higher.

Eq. (13) suggests that the value of adopting a compensation scheme linking the compensation of executive r specifically to the firm's value will be increasing in the exogenous variation in firm-performance, $(\sigma^M)^2$. In particular, we have the following hypothesis:

> Hypothesis 4: Executives will have a lower proportion of incentive pay that is equity-based if the exogenous variation in market valuation is higher.

3.3. Effect of firm size

Reduced direct monitoring of executives' efforts is likely at larger firms. This can be interpreted as a lower parameter θ_r for executives at larger firms, inducing compensation packages that rely more heavily on incentive-pay at larger firms. Larger firms may also face lower contracting costs in offering incentive-based compensation to executives, which would also suggest that larger firms would be more likely, *ceteris paribus*, to grant executives compensation based on firm performance. The assumption that large firms have a cost advantage in offering complex compensation packages is consistent with the finding that larger firms tend to pioneer the use of new forms of compensation (Fox, 1983, 1984). Thus, we have:

> Hypothesis 5: Executives at large firms will have a greater proportion of compensation that is incentive-based.

We have argued that a decrease in firm size will decrease the use of incentive pay if smaller firms can better monitor the effort of agents and if such monitoring influences the executive's future career opportunities and thus wealth. This allows a smaller firm to substitute increased monitoring for explicit incentive elements in the compensation package. However, the effect of firm size on the type of incentive pay is less clear. One could argue that larger firms not only are more likely to have higher variability in the executive-specific measure of performance, $(\sigma_r^A)^2$, but also, because of more executives, have a higher variability in the firm-value measure of performance, specifically the term $\sum_{j \neq r}(\sigma_j^V)^2$. From the above discussion and Eq. (13), we thus have the following hypothesis:

> Hypothesis 6: Executives at larger firms will have a greater proportion of incentive-based compensation that is equity-based assuming increased firm size means an increase in the variability of the executive-specific accounting performance measure relative to the firm-value measure of performance.

3.4. Effect of executive stock ownership

Executives with larger prior holdings of equity in the firm will have a greater incentive to perform independent of the current compensation package. This can be interpreted as an increase in the parameter θ_r in our model and leads to the following hypothesis:

Hypothesis 7: Executives with a larger existing ownership in the firm will have a lower proportion of compensation that is incentive-based.

We have indicated that an increase in the prior equity holdings of an executive will decrease the use of incentive pay, as larger equity holdings more closely tie the executive's wealth to effort independent of the current compensation package. In addition, a clear prediction is that executives with larger prior equity holdings will have a reduced proportion of current incentive pay tied to equity. As discussed in the appendix, if we interpret the outside-incentive parameter θ_r as the extent of prior equity holdings, then β_r^{V} in Eq. (13) would be replaced by $\beta_r^{\mathrm{V}} + \theta_r$. This follows as the prior equity holdings increase the effect of an increase in current equity compensation on the variance of income. Comparing such a modified Eq. (13) to Eq. (12) indicates a lower optimal β_r^{V} and thus yields the following hypothesis:

Hypothesis 8: Executives with a larger existing ownership in the firm will have a lower proportion of incentive-based pay that is equity-based.

3.5. Effects of R&D and market-to-book

New product development often involves a significant initial investment and a lengthy time interval until the product reaches the market. This suggests that mistakes in new product development, either failing to recognize a potential good product to develop or devoting significant resources to develop what turns out to be a bad product, can be costly. The Statement of Financial Accounting Standard No. 2 (SFAS 2) classification of research and development expenditures suggests that the magnitude of R&D expenditures can serve as an indicator of the extent of involvement by executives in new product development.[4] It follows that executives at firms with large expenditures in research and development are more likely to be involved in project selection decisions that involve new product development, where the costs of mistakes are presumed to be greater. Similarly, for firms with a high market-to-book value of assets, indicative of large intangible assets that reflect

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[4] In particular, SFAS 2 indicates that research is "planned search or critical investigation aimed at the discovery of new knowledge with the hope that such knowledge will be useful in developing a new product or service or a new process or technique or in bringing about a significant improvement to an existing product or process."

Development is "the translation of research findings or other knowledge into a plan or design for a new product or process or for a significant improvement to an existing product or process whether intended for sale or use."

market expectations of high future growth, mistakes in project selection are likely to be more costly. We thus have the following hypothesis:

> Hypothesis 9: Executives at firms with high R&D costs and firms with high market-to-book will have a higher proportion of total compensation that is incentive-based.

Bernardo et al. (2001) also suggest "managers will receive greater performance-based pay when the firm has high R&D expenditures" (p. 332). However, their prediction relies on the presumption that higher R&D increases monitoring difficulties. To have such monitoring difficulties affect compensation given their assumption of risk-neutral agents requires a further assumption, namely that greater monitoring difficulties lead to a greater aversion to effort on the executive's part.

We agree with Bernardo et al. in that firms that invest larger amounts in research and development are, by definition, more likely to realize the returns to project selection far into the future. As such, current accounting performance measures may be less precise in capturing an executive's contribution to firm value in firms with high R&D expenditures. Kole (1997) suggests that a high market-to-book value of assets also can serve as a proxy for increased difficulty in measuring managerial effort from current accounting performance measures in the presence of intangible assets that reflect market expectations of future growth opportunities. We therefore have the following hypothesis:

> Hypothesis 10: Executives at higher R&D firms and firms with a higher market-to-book value ratio will have a greater proportion of incentive-base pay that is equity-based.

4. Empirical results

The prior section identified a number of factors that are predicted to influence both the extent of use of incentive pay in general and equity-based incentive pay in particular. Our main source of data to test these predictions is Standard & Poor's (S&P's) *ExecuComp* data set that collected the details of executive compensations directly from the proxy statements of publicly traded companies in the S&P 500, S&P Midcap 400 and S&P Smallcap 600 for the years 1992 through 2000. As such, the *ExecuComp* data set contains annual executive compensation data from over 1,700 firms each year on average, for a total of 16,143 firm-year observations.

4.1. Sample data

Our analysis includes roughly 98% of the firm-year data available. Missing information on the firm's market value or assets explain the omission of 373 firm-year observations. For the remaining 15,770, there are a total of 92,135 executives identified. We remove from consideration eight executives with missing information

on salary, bonus, or restricted stock compensation. We then determine the ranking of executive positions for the remaining sample of 92,127 executives at 15,770 firm-year combinations.

The rank of an executive's position at a firm in a given year depends largely on reported total compensation paid to the executive filling the position.[5] However, in calculating the rank of positions based on the compensation of the executive holding that position, we have to be concerned with the turnover of executives. In particular, the compensation of an executive in his or her last year at the firm may reflect a partial year payment or severance pay or both. As the imposed ranks of positions within the firm are interdependent, one cannot simply drop these first- and last-year observations of an executive from the sample. Instead, we assign a departing executive a rank equal to the rank of the position held in the prior year if the executive's title is the same in both years but the exit-year rank based on compensation alone is below the prior-year rank. We then reorder the ranks of the other executive positions accordingly. In this way, the adjustment of rank for departing executives improves the classification of the rank of the positions held by the other executives.

The compensation of an executive in his or her first year at the firm may also reflect a partial-year payment. To adjust for this, we assign the new executive a rank equal to the rank of the position held in the subsequent year if the executive's title is the same in both years but the first-year rank based on compensation alone is below the subsequent-year rank and the increase in rank of the position filled is feasible given the number of executives in higher ranked positions who left the firm over the same period. While this results in cases in which more than one executive fills the same rank in a given year, one would expect this to occur if turnover leads to two executives filling the same position in the same year. Finally, if two executives in adjacent ranks have identical compensations, then the lower-ranked executive is assigned the other's rank.

ExecuComp identifies 4% of the executives who are not the highest paid at the firm, and thus fill a rank below the top-ranked position, as CEOs. This occurs even after adjusting the rank for new and departing executives for the potential effects of partial-year payment. In our analysis, we include a dummy variable to identify these individuals. To anticipate, we find that the composition of compensation differs significantly for this minority of individuals who are designated CEOs in *ExecuComp* but who are not the highest paid executive at the firm. In particular, the compensation packages for such individuals have a reduced incentive component as well as less equity-based incentive compensation.

The *ExecuComp* data set collates annual compensation information provided by large, publicly traded firms in their Securities and Exchange Commission (SEC) filings. While some companies elect to report pay beyond the five highest paid

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[5] In making this calculation, we replace missing values for compensation paid in the form of options with zeros. In our final data set, 4,175 observations omitted information on the value of compensation paid in the form of options for a particular year. We include a dummy variable in our analysis to identify these individuals. The analysis reported is robust to dropping these observations.

mandated by SEC disclosure requirements, we limit our analysis to the top five to eliminate potential sample-selection bias driven by over-reporting.[6] This eliminates 15,083 observations. Given that our analysis considers determinants of the proportion of total compensation that is incentive based and the proportion of incentive-based compensation that is equity-based, we drop from the sample 58 observations where executives had zero total compensation and nine observations where the imputed proportion of incentive pay that was equity-based exceeded one due to negative values for compensation other than salary, bonus, and equity. We thus arrive at our final sample of 76,977 executive-year observations, or 84% of all executives for which compensation data are available in our sample of firms and period.

Executive compensation can be broken into the categories of salary, bonus, equity and all other annual compensation. Note that the value of equity compensation is an expected value at the time of the grant (restricted stock grants plus Black-Scholes-valued stock options, Black and Scholes (1973)). Fig. 1 indicates that annual compensation increased over time for our sample period. For all executives in our sample, inflation-adjusted compensation in 2000 is 266% higher than that of 1992, with year 2000 total compensation at an average of $3.6 million. These findings complement Kole and Lehn (1999) findings of rising real CEO compensation for the 1971–1992 period.

Fig. 1 also illustrates the patterns of compensation for the executives by rank for three of the nine years in the sample, 1992, 1996 and 2000. Specifically, we illustrate the proportional breakdown of total compensation into three components: that which is strictly equity compensation (restricted stock plus stock options), that which is incentive but not equity compensation (bonus payments and other incentive plans) and that which is not incentive pay (salary). Note not only the increasing reliance on incentive pay over time, but also the increasing reliance on incentive pay for executives in more senior positions. In subsequent analysis, we include a trend variable to control for such changes over time.

4.2. Comparison to Kole (1997)

Our theoretical discussion has focused on the determinants of incentive pay in general, and equity-based incentive pay in specific. Table 1 describes the independent variables used in our analysis. Kole (1997) considered many of these same determinants in examining the existence of firm authorization of equity-based compensation among Fortune 500 firms using 1980 data. Our first analysis, reported in Column 2 of Table 2, updates Kole's analysis using our recent data set that measures the actual use of equity-based compensation. The dependent variable indicates whether an executive's compensation package includes equity-based compensation. For comparison purposes, Kole's original findings are reported in

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[6] The sample includes 477 firm-year observations (3% of all firm-year observations) when more than five executives were identified among the top five ranked positions either due to two or more executives having identical compensation or to turnover that resulted in more than one executive occupying a position.

Fig. 1. Compensation Characteristics By Rank and By Year. The breakdown of compensation into equity-based incentive pay, non-equity-based incentive pay and salary is shown for 1992, 1996 and 2000. In this figure, the breakdown of compensation in each year for each rank sums to 100%.

Column 1 of Table 2. Column 3 of Table 2 expands Kole's analysis by including two new independent variables, the rank of the executive's position and market return volatility. Column 4 includes firms outside the Fortune 500.

The results indicate that many of the relationships suggested by Kole regarding the existence of equity authorization plans in 1980 hold regarding the recent actual use of equity-based compensation. For instance, for our entire sample of firms, we find that executives at larger firms, at firms with higher R&D, and executives with smaller

Table 1
Variable definitions and summary statistics
Statistics for the sample of 76,977 executive-year observations from 2,407 firms. The sample period is 1992–2000.

Variable	Units	Definition (Source)	Mean (Standard deviation)
Executive-specific variables			
Executive rank	0, 1	Indicator variables: top five executives ranked according to total compensation (*ExecuComp*)	
Chief Executive Officer not top-ranked executive	0, 1	Indicator variable: individual designated chief executive officer but did not receive highest total compensation from among top five executives in the current year (*ExecuComp*)	0.032 (0.175)
Proportional rank	Ratio	Ratio of each executive's total compensation to the top executive's compensation at the firm in the same year (*ExecuComp*)	0.556 (0.300)
Executive stock ownership (Table 2)	Hundreds of thousands of dollars	Value of executive's equity holdings in the firm (*ExecuComp*)	0.307 (5.648)
Executive stock ownership (Tables 3 and 4)	Proportion	Holdings as a proportion of total shares outstanding (*ExecuComp*), for Kole (1997) comparison (Table 2)	0.010 (0.040)

Firm-specific variables

Sixty-month return volatility	Number	Standard deviation in monthly Standard & Poor's 500 returns over prior 60 months (Center for Research in Security Prices)	0.036 (0.008)
Book value of assets	Thousands of dollars	Book value of physical plant, inventories, and investments in unconsolidated subsidiaries in billions of 1999 dollars (*ExecuComp*)	8,072.177 (31,859.19)
Research and development/book value of assets	Ratio	Ratio of research and development expenditures to book value of assets, both in 1999 dollars (Compustat)	0.030 (0.102)
Market/book value of assets	Ratio	Ratio of firm's fiscal year-end market value to the book value of assets, both in 1999 dollars (Compustat)	1.622 (3.826)
Year indicator	1 to 9	Time trend variable reflecting years 1992–2000	
Industry indicators	0, 1	Indicator variables: North American Industry Classification System industries (Compustat)	
Fortune 500 firm	0, 1	Indicator variable: firm in Fortune 500 (Compustat)	0.246 (0.431)

Table 2
The use of equity-based compensation (Probit models)

For Columns (2)–(4), the dependent variable equals one if equity is part of the executive's current-year compensation. Reported coefficients are probability derivatives predicting compensation plans that include equity-based compensation. Absolute value of z-statistic in parentheses. The Huber/White/sandwich estimator of variance is used. Coefficients for the intercept, industry indicator variables, and controls for missing values are provided in a supplement.

Independent variable	Fortune 500 only			All firms
	Equity authorization plan exists at firm (Kole)[a] (1)	Equity exists as part of executive's compensation (2)	Equity exists as part of executive's compensation (3)	Equity exists as part of executive's compensation (4)
Log of the book value of assets	0.01 (1.08)	0.035 (11.05)***	0.034 (10.99)***	0.043 (21.94)***
Executive stock ownership[b]	−0.05 (0.93)	−1.044 (5.63)***	−0.852 (4.81)***	−1.260 (14.93)***
Research and development/book value of assets	0.76 (1.22)	0.401 (3.28)***	0.436 (3.59)***	0.423 (11.46)***
Market/book value of assets	0.06 (2.11)**	−0.004 (1.41)	−0.004 (1.32)	0.000 (0.15)
Rank 1 (top) executive position[c]			0.041 (4.32)***	0.090 (13.38)***
Rank 2 executive position			0.054 (5.89)***	0.080 (12.87)***
Rank 3 executive position			0.039 (4.53)***	0.057 (9.63)***
Rank 4 executive position			0.031 (3.80)***	0.036 (6.38)***

Chief executive officer designate not highest ranked		-0.241 (10.61)***	-0.246 (18.48)****
Sixty-month return volatility		-1.995 (5.52)***	-1.960 (8.56)***
Trend (1992=1)	0.016 (11.82)***	0.015 (10.63)***	0.019 (23.12)***
Firm included in Fortune 500			0.045 (7.13)***
Observations/number awarded or authorized to award equity 371/336[d]	18,947/15,826 Wald $\chi^2(25) = 1,313.6$	18,947/15,826 Wald $\chi^2(31) = 1,515.0$	76,977/56,476 Wald $\chi^2(35) = 7,319.1$

[a] For Kole's estimation (Kole, 1997) the dependent variable equals one if the firm authorizes the use of equity in compensation packages. Kole's estimation also included a variable indicating family representation either in management or on the board of directors and a variable indicating the percentage of outside directors. Asymptotic t-statistics are reported in parentheses for Column (1). Also, Kole's variable indicating executive stockholdings was at the firm level and counted directors as well as officers.

[b] Where data are available. Note that in this table we follow Kole in using the holdings as a proportion of total shares outstanding.

[c] Excluded is rank five. In general, executive positions are ranked within each firm according to total compensation received by the executive filling the position. Subject to data availability, the top five executive positions are included from each firm.

[d] Of the sample of 371 firms, 336 firms were authorized to award equity.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

stockholdings tend to be more likely to have equity-based compensation. Kole suggests that potential multicolinearity with respect to the R&D and market-to-book variables may weaken the results when these two variables are both included, and we do find here and in subsequent analysis that the predicted effect of R&D on the extent of both incentive-based and equity-based incentive compensation is strengthened if the market-to-book variable is excluded from the analysis.

4.3. Tests of hypotheses

Tables 2 and 3 provide tests of Hypotheses 1–10. Columns 1 and 2 of Table 2 provide estimates of the effect of the various firm and executive characteristics identified above on the extent of total compensation that is incentive-based. Columns 3 and 4 provide estimates of their effect on the extent of incentive compensation that is equity-based.

In estimating determinants of the proportion of compensation that is incentive pay and the proportion of incentive pay that is equity, we face a potential econometric problem in using the measured proportion as the dependent variable, for this variable is bounded in the unit interval. Such boundedness implies that the assumption of a normally distributed error term is not tenable. Recognizing this issue, we rephrase our questions concerning proportions to take the following forms: What determines the likelihood a given dollar of compensation is incentive-based? and What determines the likelihood a given dollar of incentive-based compensation is equity-based?

Columns 1 and 3 of Table 3 report the results of Probit models that accommodate our potential econometric problem and answer such questions. For this estimation procedure, we duplicate the data set and create a binary variable equal to one for the original data set and zero for the duplicate. We then weight each original observation by the observed proportion of the executive's total compensation that was incentive pay (Column 1) or the proportion of incentive pay that was awarded as equity (Column 3) and weight each duplicate observation with one minus the respective proportion.[7] Columns 2 and 4 of Table 3 report the results of fixed-effect specifications of Columns 1 and 3, respectively.[8]

Results reported in Table 3 strongly support Hypotheses 1 and 2. Not only are more senior executives more likely to have a given dollar of total compensation as incentive pay, but also they are more likely to have a given dollar of incentive pay awarded as equity. The results are striking, as the coefficients for the various ranks

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[7] As an alternative to our method of estimating Columns 1 and 3 of Table 3, one could accommodate the dependent variable in the unit interval by estimating the model on the logistically transformed proportion of compensation awarded as equity. However, while the results are not substantially affected by this monotonic transformation, we feel that the nonlinearity introduced into the dependent variable by this transformation is troublesome.

[8] The fixed-effect results reported in Tables 2 and 3 do not control for the boundedness of the dependent variable. However, the results for the entire sample reported in Columns 1 and 3 are similar to results using actual proportions as the dependent variable, so concern for the effect of not accounting for the boundedness of the dependent variable appears to be unwarranted.

Table 3
The extent of incentive-based and equity-based compensation with a simple ordering of positions
Reported coefficients for Columns (1) and (3) are probability derivatives from the estimation of Probit models. Reported coefficients for Columns (2) and (4) are estimates of fixed-effects models for an unbalanced panel of executives during their tenure at particular firms. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Coefficients for the intercept, industry indicator variables, and controls for missing values are available in a supplement.

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit) (1)	Fixed-effect model for proportion of total compensation that is incentive-based (2)	Likelihood that a given dollar of incentive compensation is equity-based (Probit) (3)	Fixed-effect model for proportion of incentive compensation that is equity-based (4)
Rank 1 (top) executive position[a]	0.156	0.235	0.090	0.252
	(43.86)***	(61.67)***	(16.80)***	(38.67)***
Rank 2 executive position	0.113	0.144	0.075	0.141
	(34.60)***	(48.22)***	(15.14)***	(27.74)***
Rank 3 executive position	0.072	0.085	0.051	0.082
	(23.59)***	(31.27)***	(10.80)***	(17.83)***
Rank 4 executive position	0.036	0.040	0.031	0.040
	(12.87)***	(15.74)***	(7.03)***	(9.24)***
Chief executive officer designate not highest ranked	−0.116	−0.026	−0.161	−0.022
	(14.92)***	(5.40)***	(15.74)***	(2.68)***
Sixty-month return volatility	−1.261	−1.328	−0.044	−0.109
	(11.36)***	(13.93)***	(0.25)	(0.67)
Log of the book value of assets	0.051	0.067	0.017	0.084
	(43.21)***	(30.59)***	(11.49)***	(22.54)***
Executive stock ownership[b]	−0.001	−0.0003	−0.003	−0.0002
	(4.60)***	(2.02)**	(1.91)*	(0.53)

Table 3 (continued)

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit) (1)	Fixed-effect model for proportion of total compensation that is incentive-based (2)	Likelihood that a given dollar of incentive compensation is equity-based (Probit) (3)	Fixed-effect model for proportion of incentive compensation that is equity-based (4)
Research and development/book value of assets	0.281 (8.09)***	−0.023 (2.51)**	0.802 (23.69)***	0.093 (5.96)***
Market/book value of assets	0.005 (3.43)***	0.006 (19.00)***	0.003 (2.60)***	0.001 (1.19)
Trend (1992 = 1)	0.020 (44.68)***	0.005 (10.85)***	0.025 (39.71)***	0.000 (0.00)
Firm included in Fortune 500	0.032 (10.22)***	0.008 (2.59)***	0.010 (2.13)**	0.005 (1.07)
Observations/number of unique executive-years	153,954[c]/76,977		152,022[d]/76,011	
Observations/number of unique executives	Wald $\chi^2(35) = 14,928.0$	76,977/20,642 $F(14, 56321) = 1,000.0$	Wald $\chi^2(35) = 7,188.8$	76,011/20,569 $F(14, 55428) = 750.9$

[a] Excluded is rank five. Executive positions are ranked within each firm according to total compensation.

[b] Where available. This variable is the percent ownership of the firm times the total value of the firm to account for the effect of differences in firm value on the value of executive's stock ownership. This contrasts with Table 2, which uses the more standard measure of executive stock ownership in terms of the proportion of total shares outstanding. Baker and Hall (1998) provide a discussion of these two measures.

[c] Only 152,833 observations contribute to the likelihood function. We arrive at this sample by doubling of the 76,977 sample less those observations with zero weights.

[d] Only 131,309 observations contribute to the likelihood function. We arrive at this sample by doubling of the 76,011 sample of those who received incentive pay less those observations with zero weights.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

are monotonically increasing across all ranks for both the extent of incentive pay and the proportion of incentive pay that is equity. Further, these differences across ranks are statistically significant with respect to each increase in seniority, from rank 5 to rank 1. Pooled-data estimates of our full sample (Columns 1 and 3 of Table 3) suggest that the top-ranked executive has a 6.9% higher likelihood that a dollar of compensation is awarded as incentive pay than the second-to-top-ranked executive, and a 2.8% higher likelihood that a dollar of incentive pay is awarded as equity.

These results of higher incentive pay and greater equity-based incentive pay at more senior positions are consistent with the assumption that executives in positions of different rank do face differences in project selection characteristics, with more senior executives evaluating projects with greater costs attached to mistakes. However, one might argue that these empirical results, especially with regard to use of incentive-based compensation, may instead reflect differences in ability, with executives in more senior positions having greater ability. Or, they may reflect differences in risk aversion across executives, with executives in more senior positions being less risk averse.

Consider first the implications of differences in ability. Greater ability can increase both the level of precision of signals on project type given no effort and the marginal impact of effort on precision. In either case the firm benefits from such higher ability and one would thus expect higher-valued alternatives for individuals with greater ability. Simulation results suggest that, of these three changes (higher precision independent of effort, greater gain in precision to increased effort, and a higher-valued alternative), only the increased marginal impact of effort on precision tends to increase the proportion of compensation that is incentive-based. The other two changes tend to reduce the proportion of compensation that is incentive-based for more able executives. Also, our simulations suggest that all three changes imply that more able executives will receive a reduced proportion of incentive pay that is equity-based. As our empirical findings do not offer strong support for such predictions, we are hesitant to adopt a theory that explains differences in the compensation composition across ranks solely on differences in executives' ability.

Now consider the implications if executives in more senior positions are less risk averse. It is the case that the optimal proportion of compensation that is incentive-based will increase with a decrease in the executive's aversion to risk. In fact, if one assumes that the salary component of compensation is not bounded from below, then the limiting case of a risk-neutral executive has the weights β_r^A and β_r^V summing to one, a likely negative salary component, and a proportion of total compensation that is incentive based that exceeds one. If we accept the view that executives of different ranks are paid differently solely due to differences in their aversion to risk, then no change would be predicted in the compensation package for the same executive who changes rank. However, this prediction is not consistent with the estimation results for the fixed-effect model (Column 2 of Table 3) that controls for executive-specific effects and estimates the effect of rank for executives who changed rank at a firm within the nine-year period of our sample. For instance, the estimates suggest that there is a 14.7% increase in the proportion of compensation that is incentive-based for one moving from the second-ranked to the top-ranked position.

Hypotheses 3 and 4 suggest that increased exogenous volatility in firm value will lead firms to reduce the use of incentive pay, in particular equity-based incentive pay. To test Hypotheses 3 and 4, we have to generate a measure of return volatility that is independent of the outcomes of past project decisions of the executives at the firm. This means that we have to be careful in using measures that are tied directly to the firm's return volatility. The reason for this is as follows. From Eq. (3), we know that the past volatility of a firm's value will reflect not only the exogenous market shocks that we seek to measure but also the outcome of the decisions made by the firm's executives. At firms where the executives' decisions are more important in terms of evaluating projects with greater costs attached to mistakes, we expect not only greater volatility in the firm's value but also more weight at such firms attached to incentive-based pay for all executives. This implies that increased firm-specific volatility will be associated with increased use of incentive-based use of incentive pay.

In an attempt to minimize the above measurement problem, our market return volatility measure is calculated as the standard deviation in the overall monthly return for all S&P 500 firms over the previous 60 months as reported in data provided by the Center for Research in Security Prices (CRSP). As we indicate in Appendix A, this aggregate measure provides a cleaner measure of exogenous market shocks as it is less directly tied to firm-specific outcomes. Using this measure, we find support for Hypothesis 3 regarding the effect of volatility in firm value on the use of incentive compensation. However, these results do not carry over with respect to the use of equity-based incentive pay, and so we are left with no clear evidence in favor of Hypothesis 4. We suspect the reason for this is the lack of a precise measure of the variance $(\sigma^M)^2$ in the exogenous shocks to a firm's market value (ε^M), shocks that we have assumed are independent of both executives project decisions and errors in accounting measures of performance.

Hypotheses 5 and 6 identify firm size as another important potential determinant of the use of incentive pay in general and equity-based incentive pay in particular. The results reported in Table 3 also support these two hypotheses. Executives at larger firms are more likely to receive incentive-based pay and are more likely to have such pay be equity-based. An executive employed in a firm that is at the median of the upper quartile in assets is 40.7% more likely to receive a given compensation-dollar as incentive pay and 14.7% more likely to receive a given dollar of incentive pay as equity-based compensation. Further, the fixed-effects results indicate this applies for the pooled sample and for specific executives as the size of their firm changes.

Hypotheses 7 and 8 suggest that greater prior stock ownership will reduce the extent to which compensation is incentive-based as well as the proportion of incentive-based compensation that is equity-based. Our results provide partial support for these hypotheses. In particular, the pooled sample estimates indicate that as the equity holdings of an executive increase over time, less compensation will be incentive-based and less incentive-based compensation will be equity-based. However, the economic significance of the point estimates is marginal, and the second result is not found in our fixed-effect model estimation for equity-based pay.

Finally, Hypotheses 9 and 10 link the increased use of incentive pay and equity-based incentive pay to greater R&D and to higher market-to-book values. We find some support for these hypotheses in the results reported in Table 3. For our pooled sample, an executive employed in a firm that is at the median of the upper quartile in market-to-book value or in R&D intensity is 2.2% and 3.8%, respectively, more likely to receive a given compensation dollar as incentive-based pay and 1.4% and 13.9%, respectively, more likely to receive a given incentive-based compensation dollar as equity than an executive employed in a firm that is at the median of the corresponding lower quartile. However, the fixed-effects model reverses the R&D result for the use of incentive pay. That is, as a firm becomes more research intensive, a given executive at this firm is less likely to receive a dollar of compensation as incentive pay.

One possible way to reconcile these findings is as follows. We have interpreted high R&D expenditures to reflect a climate in which more important decisions are made (in the sense that decision mistakes are more costly), and our theory predicts that in such situations the advantage to incentive pay is greater. This explains the pooled-sample result. What the fixed-effects result could indicate is that important R&D decisions precede in time the actual R&D expenditures. Thus, a year of low (below average for the firm) R&D expenditures is one in which executives are making important decisions regarding substantial future R&D expenditures and thus more weight is attached to incentive pay to induce more accurate decision-making during such times. This suggests that a potentially fruitful area to explore is the interplay between the timing of R&D expenditures and the composition of compensation. Dropping the market-to-book variable from the fixed-effect estimation does yield the predicted positive effect of R&D on the use of equity-based incentive pay.

Our empirical work, as it employs a timely data set that is more comprehensive than those used in earlier papers, offers an opportunity to update and reexamine earlier findings. For instance, Lambert and Larcker (1988), Core and Guay (1999), and Natarajan (1996) are examples of papers that analyze the use of accounting-based versus stock-based performance measures in CEO compensation.[9] Lambert and Larcker consider a sample of 370 firms from 1970 to 1984, while Core and Guay rely on the *ExecuComp* database, although their analysis is restricted to CEOs and covers the period from 1992 to 1997. One aspect of the empirical work in these papers that differs from ours is a focus on testable hypotheses in terms of relative weights attached to various performance measures. Our approach suggests a focus on the resulting proportion of compensation that is incentive-based and the resulting proportion of incentive-based compensation that is equity-based. Nevertheless, consistencies exist across the findings in these papers and our findings.

Lambert and Larcker also report that the relative weight in the compensation package assigned to a firm's market return versus an accounting measure of performance is an increasing function of the relative noise of the firm's accounting measure. These results are compatible with our finding that the proportion of

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[9] Others include Sloan (1993), Bushman and Indjejikian (1993), and Baiman and Verrecchia (1995).

incentive-based compensation that is equity-based increases with higher R&D expenditures (as a proxy for increased noise in accounting measures of performance). Similarly, Core and Guay's finding that larger firms place increased weight on equity incentives mirrors our finding.

Natarajan (1996) considers how various accounting measures of performance such as net income and working capital from operations determine CEO total compensation for a time series of 331 firms over the period 1970–1988. He establishes that the weights attached to these various accounting measures tend to be smaller at larger firms and at firms with higher market-to-book ratios. One can interpret Natarajan's findings as indicating a decreased reliance on accounting measures for CEO compensation packages at larger firms and firms with higher market-to-book ratios. If we adopt this interpretation, then Natarajan's findings are consistent with our cross-sectional findings that executives at such firms have a greater proportion of incentive compensation that is equity-based. However, our findings could not be deduced immediately from Natarajan's. For instance, one could obtain Natarajan's findings if the correlation between firm value and the accounting measures was less at larger firms, even if firms of different sizes devoted the same positive fraction of total compensation to equity-based compensation.

4.4. Robustness of results to alternative rank measures

An important finding of the above empirical analysis is the systematic difference in the composition of compensation depending on an executive's position rank as indicated by the relative total compensation of the executives (ranks 1–5). Our measures of rank based on compensation is adjusted in the case of executives in their first or last year at the firm, as compensation in such cases may not accurately capture the relative position of the new or departing executive.[10] However, such modifications do not alter our findings. Below we outline five alternatives we tried to test the robustness of our rank results. First, we reestimated the equations reported in Table 3 using the rank measures that do not correct for the fact that a particular executive is in his or her first or last year at the firm and thus may have a compensation measure that reflects a partial-year payment. The result remains that the use of incentive pay and equity pay as a proportion of incentive pay are both monotonically increasing in executive seniority.

For our second alternative, we retained our preferred rank measures that make adjustments for new and departing executives, but we introduced new variables that interact these rank variables with dummy variables indicating if the executive is in his or her first year or last year to see if the effect of rank on the composition of compensation differs for such individuals. Again we find that the rank results are robust to this specification in that the use of incentive pay and equity pay as a proportion of incentive pay are monotonically increasing in executive seniority. Further, we find that the use of both incentive pay and equity pay as a proportion of

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[10] As *ExecuComp* data contains information only on the top five executives, we can only observe arrival and departure from the top five positions in the firm, not true arrival and departure from the firm, per se.

incentive pay tend to be higher for executives who are new to the top five, suggesting that the rank of these executives is underestimated. The use of incentive pay and equity pay as a proportion of incentive pay tend to be lower for executives who are in their departing year, which suggests that the rank of these executives is over-estimated.

Our third alternative specification is like the second one, but with the addition of variables that interact the rank measures with dummy variables that indicate the executive is at a firm that experienced a departure of an executive or an arrival of a new executive in that year. This captures the possibility that if our adjusted rank measures do not fully reflect the true rank of a new or departing executive, then this can distort the rank measures for some of other individuals at the firm where such turnover occurred. As in the two alternative specifications above, here we also find that the rank results are robust. Furthermore, equity pay as a proportion of incentive pay tends to be higher in firms experiencing transition.

Top executives in some firms could act as a team, with decisions arrived at through consensus or by a rotation of leadership roles. In such cases, one could argue that a similar rank should be assigned to these positions, as they are similar in the importance of the decisions being made. It follows that we would expect individuals in these positions to receive similar compensation packages. Table 4 provides estimates using an alternative measure of a position's rank that accommodates positions that are similar in compensation and thus importance. Specifically, in Table 4 a position's rank is defined by the ratio of total compensation of the executive in the position to the highest compensation at the firm in the same year. In the vast majority of cases, the top compensation is the CEO's compensation.

This new measure of rank has the potential to be a more accurate reflection of the relative importance of decision-making across positions for two reasons. First, to the extent executives are in positions of similar importance, possibly reflecting a sharing of decision-making responsibilities, and thus similar compensation, this new measure of a position's rank appropriately assigns these individuals a similar rank. Now consider two individuals whose compensation differ substantially. This suggests a substantial difference in the importance of projects being evaluated, and this new measure of position rank as a proportion of the top executive's compensation would reflect this substantial difference.

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

Table 4
The extent of incentive-based and equity-based compensation with positions ranked by proportion of top executive's compensation
Reported coefficients for Columns (1) and (3) are probability derivatives from the estimation of Probit models. Reported coefficients for Columns (2) and (4) are estimates of fixed-effects models for an unbalanced panel of executives during their tenure at particular firms. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Coefficients on an intercept, industry indicator variables, and controls for missing values shown in a supplement.

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit) (1)	Fixed-effect model for proportion of total compensation that is incentive-based (2)	Likelihood that a given dollar of incentive compensation is equity-based (Probit) (3)	Fixed-effect model for proportion of incentive compensation that is equity-based (4)
Proportional rank of executive's position[a]	0.166	0.234	0.076	0.275
	(40.30)***	(57.55)***	(12.81)***	(39.77)***
Chief executive officer designate not highest ranked	−0.120	−0.058	−0.159	−0.059
	(15.73)***	(13.33)***	(15.83)***	(7.99)***
Sixty-month return volatility	−1.193	−1.169	0.006	0.044
	(10.70)***	(12.17)***	(0.03)	(0.27)
Log of the book value of assets	0.052	0.065	0.017	0.084
	(43.87)***	(29.59)***	(11.66)***	(22.52)***
Executive stock ownership[b]	−0.001	−0.0003	−0.003	−0.0002
	(4.60)***	(1.92)*	(1.91)*	(0.54)
Research and development/book value of assets	0.278	−0.026	0.799	0.090
	(8.09)***	(2.83)***	(23.75)***	(5.78)***

Market/book value of assets	0.005 (3.47)***	0.006 (19.01)***	0.003 (2.63)***	0.001 (1.43)
Trend (1992=1)	0.020 (45.53)***	0.007 (15.18)***	0.025 (39.80)***	0.002 (2.45)**
Firm included in Fortune 500	0.031 (9.85)***	0.006 (2.14)**	0.009 (2.04)**	0.004 (0.73)
Observations/number of unique executive-years	153,954[c]/76,977	76,977/20,642		
Observations/number of unique executive			152,022[d]/76,011	76,011/20,569
	Wald $\chi^2(32) = 14{,}127.8$	$F(11, 56324) = 1{,}161.4$	Wald $\chi^2(32) = 7{,}034.0$	$F(11, 55431) = 948.0$

[a] Executive positions are ranked within each firm in terms of the executive's total compensation as a proportion of the top executive's total compensation.

[b] Where available. This variable is the percent ownership of the firm times the total value of the firm to account for the effect of differences in firm value on the value of executive's stock ownership. This contrasts with Table 2, which uses the more standard measure of executive stock ownership in terms of the proportion of total shares outstanding. Baker and Hall (1998) provide a discussion of these two measures.

[c] Only 152,833 observations contribute to the likelihood function. We arrive at this sample by doubling of the 77,016 sample less those observations with zero weights

[d] Only 131,309 observations contribute to the likelihood function. We arrive at this sample by doubling of the 76,011 sample of those who received incentive pay less those observations with zero weights.

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

the prior year for a departing executive or with the ratio in the subsequent year for a new executive.

Our empirical results of Table 4 provide support for the idea that compensation will differ across positions that are different in rank using an alternative approach to ranking positions. Positions that are ranked higher in terms of offering compensation closer to that of the top executive have a greater proportion of compensation that is incentive-based as well as a greater proportion of incentive-based compensation that is equity-based. In particular, the estimates of Table 4 suggest that relative to an executive whose proportional-rank measure is at the medium of the lower quartile, a top executive is 22.8% more likely to receive a given compensation dollar as incentive pay and 12.2% more likely to receive a given dollar of incentive pay as equity-based compensation. Further, the fixed-effects results indicate this applies not only for the pooled sample, but also for specific executives as their relative importance changes. The findings in Table 4 regarding variables other than position-rank confirm those reported in Table 3.

Finally, for our measure of rank in terms of the proportion of compensation relative to the CEO (results reported in Table 4), we added variables that interact this rank measure with dummy variables indicating if the executive is in his first or in his last year. In this case, the rank measure of other executives at the firm is not affected by such turnover so further adjustments along the lines of the third alternative described above are not required. We find that the proportional rank result remains robust to this specification. Beyond this, we again find that the use of both incentive pay and equity pay as a proportion of incentive pay tend to be higher for executives who are new to the top five and lower for executives who are in their departing year.

5. Conclusion

This paper investigates executive compensation using an expanded principal-agent model that focuses on project selection. There are three key distinguishing features of our paper. First, hypotheses regarding executive compensation are formally developed in the context of a project selection principal-agent model and tested using a large data set of U.S. firms for the 1992 to 2000 period. Second, the paper's empirical analysis on the proportion of executive compensation that is incentive-based and the proportion of incentive-based compensation that is equity-based is linked to earlier work on ex ante compensation and affirms the findings of Kole (1997). Third, the characteristics of compensation packages for executives below the CEO level are treated both theoretically and empirically. The predictions that executives of higher rank, because of their more pronounced impact on the firm's stock appreciation, will not only have a greater proportion of compensation incentive based, but also a greater proportion of incentive-based compensation that is equity-based, hold as well.

The effect of executive rank in this paper has focused on the view that the project selection of more senior executives has a greater impact on the value of the firm. However, if one were to view the project selection process as hierarchical among the top five executives, such that an executive of a particular seniority only evaluates projects approved by executives of lower seniority, then a key difference in projects evaluated across ranks would be that more senior executives evaluate projects that are more likely to be good. Simulations of our model indicate that an increase in the probability of a good project (α_r) would lead to a reduction in the optimal level of effort and a reduced proportion of compensation that is incentive-based. Yet we find the opposite in the empirical analysis, suggesting that our original view that more senior executives evaluate projects of greater impact on the firm may be the more useful characterization of the differences across ranks, at least for the five most senior executives at the firm.

The project selection model presented in this paper has two attractive features. First, it formalizes our understanding of the roles played by the various variables used in the empirical analysis on the extent of incentive-based and equity-based compensation. For instance, the relative informativeness of performance signals is shown to be an important element in interpreting the effect of such firm characteristics as R&D and the market-to-book ratio on the structure of executive compensation.

Second, the model allows one to identify a potential trade-off between various types of equity-based compensation, in particular restricted stock grants versus stock options. Expanding our analysis, one can identify a leverage advantage to stock options that enhances their effectiveness in inducing an executive to increase efforts toward determining the true value of a proposed project. However, options, by limiting the effect of type 2 errors on compensation, provide an executive with a different perspective on optimal project selection than that of shareholders, one that can lead the executive to accept a project that, *ceteris paribus*, shareholders would rather reject.

Thus, within the context of project selection, stock options offer the trade-off of encouraging increased effort but at the expense of introducing a bias in the project acceptance decision. Preliminary empirical evidence suggests that for the highest ranks, executives receive relatively less of their equity compensation in the form of stock options when compared with lower ranking executives, suggesting that the adverse effect of options on project selection criteria grows relatively more important at higher ranks. Further work along these lines is considered in Barron and Waddell (2002a), which provides a more extensive treatment, both theoretically and empirically, with regard to this trade-off. In so doing, issues such as the effect of stock options on the nature of the variance in income of the agent are considered.

Other potential extensions of the paper suggested by the theory can draw upon the extensive *ExecuComp* data set. For instance, we have cited prior stock holdings and firm size (through monitoring effectiveness) as variables that reflect the magnitude of the outside-incentive parameter θ_r. However, one could also consider executives

below the top executive as engaged in a tournament, in which case the increase in expected compensation from a movement to a more senior rank becomes another measure of an incentive that is separate from or outside current compensation. In this light, the results in Table 4 could be interpreted as indicating that those reaping a greater gain in terms of the compensation increase if they become the CEO at the firm will receive less incentive pay in part due to the substitution of tournament-incentives for compensation-based incentives. Further work along these lines is considered in Barron and Waddell (2002b). For related discussion, consult Bognanno (2001).

Another potential extension of the paper that can benefit from the rich *ExecuComp* data set is to examine in more detail the nature of compensation-composition differences across ranks for firms of different characteristics. For instance, preliminary findings suggest that the increase in the proportion of compensation that is incentive pay and equity-based incentive pay at more senior ranks is more pronounced at firms with a higher R&D expenditures to asset ratio. This suggests further study of such issues, both theoretical and empirical, is warranted.

Appendix A

This appendix shows how one can obtain our simple characterization of the optimal compensation package in terms of the proportion of incentive pay that is equity-based and provides a justification for our focus on the variance in aggregate returns to measure market uncertainty. First, consider our characterization of the optimal current compensation package. The standard principal-agent maximization problem, with shareholders as the principal and executives as the agents, can be simplified by first substituting the individual rationality constraints related to the current compensation package (certainty equivalent) into the firm's objective function. Given reservation utility u for the executive in position r, this yields the following problem:

$$\max_{\substack{e_r, \beta_r^A, \beta_r^V \\ r=1,\ldots,n}} \sum_{r=1}^{n} \mathrm{E}(V_r(e_r, \hat{s}_r)) - \sum_{r=1}^{n} (u + (1/2)e_r^2 + (1/2)\gamma\sigma_r^2), \tag{A.1}$$

subject to the incentive compatibility constraints that

$$e_r = (\beta_r^A + \beta_r^V + \theta_r)$$

$$\times \left[-\alpha_r \frac{\partial F_{\mathrm{G}}(e_r, \hat{s}_r)}{\partial e_r}(V_r^{\mathrm{G}} - V_r^0) - (1 - \alpha_r)\frac{\partial(1 - F_{\mathrm{B}}(e_r, \hat{s}_r))}{\partial e_r}(V_r^0 - V_r^{\mathrm{B}}) \right]$$

$$- 1/2\gamma\frac{\partial\sigma_r^2}{\partial e_r}$$

for all r. We adopt the first-order approach to characterizing the incentive compatibility constraints. See Rogerson (1985), among others, for a discussion of this approach.

The marginal impact of effort on the executive's wealth outside the current compensation package is captured by the parameter θ_r. This parameter could reflect future career opportunities that are linked to recommendations based on information other than that reflected in the performance measures, such as information obtained through the direct monitoring of the executive by the firm's directors or other executives. Alternatively, the parameter θ_r could reflect the impact of effort on the value of the executive's previously acquired equity holdings. If we adopt this view, then several other modifications have to be made to the above statement of the problem. First, we have to modify the form of the variance term in the incentive compatibility constraint to incorporate the effect of effort on the variance in the value of the stock holdings that are not part of the current compensation package. Second, we have to adjust the executive's individual rationality constraint to recognize the fact that the increment in variance to accepting the compensation package includes an additional term that reflects the increased exposure to risk (variance) that arises when the stock holdings specified by the compensation contract are added to an existing level of equity holdings.

From the incentive compatibility constraint, we can write the implicit solution for the optimal evaluation effort of the executive assigned to position r as

$$e_r^{**} = g(\beta_r^A, \beta_r^V, \theta_r, \gamma, (V_r^G - V_r^0), (V_r^0 - V_r^B), \alpha_r), \tag{A.2}$$

where $g_1 > 0$ and $g_2 > 0$. Substituting (A.2) into the firm's objective, (A.1) simplifies further to

$$\max_{\substack{\beta_r^A, \beta_r^V \\ \forall r}} \sum_{r=1}^{n} E(V_r(g(\cdot))) - \sum_{r=1}^{n} (u + (1/2)g(\cdot)^2 + (1/2)\gamma\sigma_r^2). \tag{A.3}$$

From the first-order conditions for the compensation weights β_r^A and β_r^V, ignoring for the moment the role of incentives outside the current compensation package (i.e., setting $\theta_r = 0$), we obtain the following relationship:

$$\frac{\beta_r^V}{\beta_r^A} = \frac{(w_r^A \sigma^A)^2}{\sum_{j \neq r}(w_j^V \sigma_j^V)^2 + (w^M \sigma^M)^2}. \tag{A.4}$$

The solution indicates that the optimal executive contracts always include a strictly positive weight on both measures if both are imperfect measures. This is an expected result. For instance, Holmström (1979) demonstrated that where an informative performance measure is costless to employ, the firm would always attach some strictly positive weight to the measure. However, evidence shows that this is not empirically supported in the compensation of executives. For instance, roughly 15% of executives in the most recent year of our sample (2000) do not receive equity-based compensation. This suggests the existence of some fixed contracting cost to the firm of implementing an equity compensation program for each executive that we have not formally modeled.

With symmetry, $w_r^V = \alpha_r(V_r^G - V_r^0) = (1 - \alpha_r)(V_r^0 - V_r^B)$. This suggests that the magnitude of the weight w_r^V on the project error component is an increasing, concave function of the expected value of the project. We expect the weight on the accounting measure error term, w_r^A, to also be an increasing, concave function of the expected value of the project. Finally, the weight w^M that determines the magnitude of deviations in firm value from its expected level reflecting overall market shocks is expected to be an increasing, concave function of the expected value of the firm. If we adopt the specific functional forms for these relationships $w_r^A = (E(A_r))^{1/2}$, $w_r^V = (E(V_r))^{1/2}$, and $w_r^M = (E(V))^{1/2}$, then Eq. (A.4) can be rewritten as

$$\frac{\beta_r^V E(V)}{\beta_r^A E(A_r)} = \frac{(\sigma^A)^2}{\sum_{j \neq r}(E(V_j)/E(V))(\sigma_j^V)^2 + (\sigma^M)^2} \tag{A.5}$$

given $E(A_r) = E(V_r)$ from Eq. (7). Rearranging Eq. (A.5), we obtain Eq. (13) that identifies the determinants of the proportion of incentive based compensation that is equity-based. If the parameter θ_r is defined as equal to the executive's prior share of equity holdings in the firm, then the modifications of the incentive compatibility and individual rationality constraints discussed above will result in a modified Eq. (A.5), with $\beta_r^V + \theta_r$ replacing β_r^V.

Now let's consider a justification for our measure of the variance σ^M in the market shock component that is derived from the variance in aggregate rates of return. We can rewrite the firm value expression [Eq. (3)] as

$$V_t = V_{t-1}(1 + r_t^e) + \sum_{r=1}^{n}[w_r^V \varepsilon_r] + w^M \varepsilon^M \tag{A.6}$$

where r_t^e, the expected rate of return in period t, is defined as $(E(V_t) - V_{t-1})/V_{t-1}$. The realized rate of return can then be expressed as

$$r_t \equiv (V_t - V_{t-1})/V_{t-1} = r_t^e + \sum_{r=1}^{n}\omega_r^V \varepsilon_r + \omega^M \varepsilon^M \tag{A.7}$$

where $\omega_r^V \equiv w_r^V/V_{t-1}$ and $\omega^M \equiv w^M/V_{t-1}$. Eq. (A.7) illustrates that a firm's realized return differs from the expected return due to the random components of the project outcomes for each of the n executives ($\varepsilon_r, r = 1, ..., n$) and the random component reflecting exogenous market events (ε^M).

Now consider the average return across S firms. To provide an explicit expression for this average return, we introduce superscripts i to denote firm i, $i = 1, ..., S$. Before, we omitted such superscripts for notational simplicity. The average return across the S firms is defined by $r_t^a \equiv \sum_{i=1}^{s} r_t^i/S$. Substituting the definition of individual firms' rates of return Eq. (A.6) results in

$$r_t^a \equiv r_t^{ae} + \sum_{i=1}^{s}\sum_{r=1}^{n}\omega_r^{Vi}\varepsilon_r^i/S + \sum_{i=1}^{s}\omega^{Mi}\varepsilon^M/S, \tag{A.8}$$

where $r_t^{ae} \equiv \sum_{i=1}^{S} r_t^{ei}$ denotes the average of the expected returns across the S firms.

We have assumed the random terms ε_r^i are independent across the r executives and across the S firms and that the market shock ε^M is independent of the firm-specific

random components ε_r^i. This means that as the number of firms in the average increases (higher S), the variance in r_t^a approaches a term that involves only the variance in the market shock, $(\sigma^M)^2$. In particular, if we assume identical weights across firms, such that $\omega_r^V = \omega_r^{Vi}$ for all ranks r and firms i and that $\omega^M = \omega^{Mi}$ for all firms i, then the variance in the average return r_t^a is given by

$$E(r_t^a - E(r_t^a))^2 = \sum_{r=1}^{n} (\omega_r^V \sigma^V)^2 / S + (\omega^M \sigma^M)^2 \qquad (A.9)$$

From Eq. (A.9), it is clear that as S increases, the first term goes to zero, and the variance in the average return approaches a scaled measure of the variance in the exogenous market shock, $(\sigma^M)^2$. In the paper, we use the variance in the returns across all firms that comprise the S&P 500 in a given year to approximate the variance in the exogenous market shock (Tables A.1–A.3).

Table A.1
Table 2 coefficients not reported in the paper

Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Industry indicators are drawn from the North American Industry Classification System (NAICS).

Independent variable	Fortune 500 only		All firms
	Equity exists as part of executive's compensation (1)	Equity exists as part of executive's compensation (2)	Equity exists as part of executive's compensation (3)
Agriculture, forestry, fishing, and hunting (NAICS=11)	0.064	0.056	0.005
	(0.75)	(0.64)	(0.11)
Mining (NAICS=21)	0.044	0.048	0.030
	(1.92)*	(2.16)**	(2.43)**
Utilities (NAICS=22)	−0.230	−0.237	−0.261
	(10.16)***	(10.48)***	(18.43)***
Construction (NAICS=23)	−0.073	−0.070	−0.033
	(1.87)*	(1.86)*	(1.37)
Manufacturing (NAICS=31)	−0.042	−0.043	−0.047
	(2.62)***	(2.67)***	(3.68)***
Manufacturing (NAICS=32)	0.025	0.024	0.000
	(2.36)**	(2.33)**	(0.02)
Wholesale trade (NAICS=42)	0.006	0.001	−0.032
	(0.46)	(0.10)	(2.47)**
Retail trade (NAICS=44)	−0.036	−0.040	−0.064
	(1.76)*	(2.00)**	(4.46)***
Retail trade (NAICS=45)	−0.007	−0.006	0.014
	(0.34)	(0.32)	(0.84)
Transportation and warehousing (NAICS=48)	−0.079	−0.079	−0.062
	(2.97)***	(3.05)***	(3.60)***
Transportation and warehousing (NAICS=49)	0.062	0.059	0.108
	(1.68)*	(1.58)	(2.61)***

Table A.1 (*continued*)

Independent variable	Fortune 500 only		All firms
	Equity exists as part of executive's compensation (1)	Equity exists as part of executive's compensation (2)	Equity exists as part of executive's compensation (3)
Information (NAICS=51)	−0.037	−0.036	−0.033
	(1.98)**	(1.95)*	(3.40)***
Finance and insurance (NAICS=52)	−0.060	−0.063	−0.059
	(3.33)***	(3.45)***	(5.93)***
Real estate and rental and leasing (NAICS=53)	0.089	0.085	−0.007
	(1.99)**	(2.03)**	(0.26)
Professional, scientific and technical Services (NAICS=54)	−0.075	−0.072	−0.007
	(2.83)***	(2.72)***	(0.51)
Administrative and support and waste management and remediation services (NAICS=56)	0.036	0.026	−0.003
	(0.91)	(0.67)	(0.21)
Educational services (NAICS=61)	No observations	No observations	0.024
			(0.46)
Health care and social assistance (NAICS=62)	−0.006	−0.000	0.004
	(0.18)	(0.01)	(0.29)
Arts, entertainment and recreation (NAICS=71)	No observations	No observations	−0.102
			(3.18)***
Accommodation and food services (NAICS=72)	0.001	−0.000	−0.016
	(0.03)	(0.01)	(1.01)
Other services (except public administration) (NAICS=81)	Dropped[a]	Dropped[a]	−0.040
			(0.87)
Share ownership not available	−0.144	−0.133	−0.395
	(6.62)***	(6.15)***	(36.01)***
Option value missing (set equal to zero)	−0.318	−0.300	−0.322
	(13.76)***	(13.03)***	(27.05)***

[a] All five observations from the industry "Other services (except public administration)" (NAICS = 81) are associated with the same outcome in Columns (1) and (2). Therefore, this variable and the associated observations are dropped from the estimation procedure.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

Table A.2
Table 3 coefficients not reported in the paper
Reported coefficients for Columns (1) and (3) are probability derivatives from estimation of Probit models. Reported coefficients for Columns (2) and (4) are estimates of fixed-effects models for an unbalanced panel of executives during their tenure at particular firms. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Industry indicators are drawn from the North American Industry Classification System (NAICS).

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit)	Fixed-effect model for proportion of total compensation that is incentive-based	Likelihood that a given dollar of incentive compensation is equity-based (Probit)	Fixed-effect model for proportion of incentive compensation that is equity-based
	(1)	(2)	(3)	(4)
Agriculture, forestry, fishing, and hunting (NAICS=11)	-0.065	—	-0.044	—
	(2.84)***		(1.55)	
Mining (NAICS=21)	-0.007	—	0.066	—
	(1.13)		(6.89)***	
Utilities (NAICS=22)	-0.228	—	-0.194	—
	(37.87)***		(21.47)***	
Construction (NAICS=23)	0.026	—	-0.095	—
	(2.54)**		(5.71)***	
Manufacturing (NAICS=31)	-0.056	—	-0.018	—
	(8.53)***		(1.87)*	
Manufacturing (NAICS=32)	-0.041	—	-0.002	—
	(9.60)***		(0.28)	
Wholesale trade (NAICS=42)	-0.042	—	-0.003	—
	(6.13)***		(0.29)	
Retail trade (NAICS=44)	-0.051	—	0.020	—
	(7.47)***		(1.83)*	

Table A.2

Table 3coefficients not reported in the paper

Reported coefficients for Columns (1) and (3) are probability derivatives from estimation of Probit models. Reported coefficients for Columns (2) and (4) are estimates of fixed-effects models for an unbalanced panel of executives during their tenure at particular firms. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Industry indicators are drawn from the North American Industry Classification System (NAICS).

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit) (1)	Fixed-effect model for proportion of total compensation that is incentive-based (2)	Likelihood that a given dollar of incentive compensation is equity-based (Probit) (3)	Fixed-effect model for proportion of incentive compensation that is equity-based (4)
Retail trade (NAICS=45)	−0.025 (2.59)***	—	0.110 (8.10)***	—
Transportation and warehousing (NAICS=48)	−0.034 (3.43)***	—	0.002 (0.18)	—
Transportation and warehousing (NAICS=49)	−0.062 (2.97)***	—	0.109 (3.59)***	—
Information (NAICS=51)	0.037 (7.31)***	—	0.046 (6.30)***	—
Finance and insurance (NAICS=52)	−0.053 (10.06)***	—	−0.053 (7.79)***	—
Real estate and rental and leasing (NAICS=53)	−0.013 (0.57)	—	0.030 (1.45)	—
Professional, scientific and technical Services (NAICS=54)	0.004 (0.45)	—	0.030 (2.76)***	—
Administrative and support and waste management and Remediation services	−0.020 (1.71)*	—	0.079 (5.33)***	—

	(1)	(2)	(3)	(4)
(NAICS=56) Educational services (NAICS=61)	−0.004 (0.20)	—	−0.030 (0.79)	—
Health care and social assistance (NAICS=62)	0.046 (5.33)***	—	0.126 (10.07)***	—
Arts, entertainment and recreation (NAICS=71)	−0.001 (0.06)	—	0.068 (2.22)**	—
Accommodation and food services (NAICS=72)	−0.011 (1.22)	—	0.058 (4.61)***	—
Other services (except public administration) (NAICS=81)	−0.083 (1.22)	—	−0.031 (1.03)	—
Share ownership not available	−0.079 (2.50)**	−0.091	−0.266	−0.207
Option value missing (set equal to zero)	−0.065 (14.38)***	−0.090 (21.97)***	−0.241 (29.19)***	−0.242 (28.51)***
Constant	— (11.59)***	0.023 (21.27)***	— (24.16)***	−0.229 (32.71)***
		(1.56)		(8.88)***

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

Table A.3
Table 4 coefficients not reported in the paper

Reported coefficients for Columns (1) and (3) are probability derivatives from estimation of Probit models. Reported coefficients for Columns (2) and (4) are estimates of fixed-effects models for an unbalanced panel of executives during their tenure at particular firms. Absolute value of z-statistic is in parentheses. The Huber/White/sandwich estimator of variance is used. Industry indicators are drawn from the North American Industry Classification System (NAICS).

Independent variable	Extent of total compensation that is incentive-based		Extent of incentive-based compensation that is equity	
	Likelihood that a given dollar of total compensation is incentive-based (Probit)	Fixed-effect model for proportion of total compensation that is incentive-based	Likelihood that a given dollar of incentive compensation is equity-based (Probit)	Fixed-effect model for proportion of incentive compensation that is equity-based
	(1)	(2)	(3)	(4)
Agriculture, forestry, fishing, and hunting (NAICS=11)	−0.066	—	−0.045	—
	(2.89)***		(1.57)	
Mining (NAICS=21)	−0.008	—	0.066	—
	(1.16)		(6.86)***	
Utilities (NAICS=22)	−0.232	—	−0.196	—
	(38.34)***		(21.71)***	
Construction (NAICS=23)	0.026	—	−0.095	—
	(2.48)**		(5.71)***	
Manufacturing (NAICS=31)	−0.058	—	−0.019	—
	(8.68)***		(1.95)*	
Manufacturing (NAICS=32)	−0.042	—	−0.002	—
	(9.79)***		(0.38)	
Wholesale trade (NAICS=42)	−0.043	—	−0.003	—
	(6.25)***		(0.35)	
Retail trade (NAICS=44)	−0.056	—	0.017	—
	(8.11)***		(1.58)	
Retail trade (NAICS=45)	−0.028	—	0.109	—
	(2.87)***		(8.02)***	
Transportation and warehousing (NAICS=48)	−0.036	—	0.002	—
	(3.58)***		(0.14)	
Transportation and warehousing (NAICS=49)	−0.071	—	0.105	—
	(3.58)***		(3.42)***	

	(1)	(2)	(3)
Information (NAICS=51)	0.036 (7.14)***	0.046 (6.24)***	—
Finance and insurance (NAICS=52)	-0.056 (10.71)***	-0.055 (7.95)***	—
Real estate and rental and leasing (NAICS=53)	-0.016 (0.73)	0.029 (1.38)	—
Professional, scientific and technical services (NAICS=54)	-0.001 (0.14)	0.027 (2.51)**	—
Administrative and support and waste management and Remediation services (NAICS=56)	-0.020 (1.68)*	0.079 (5.37)***	—
Educational services (NAICS=61)	-0.010 (0.46)	-0.033 (0.88)	—
Health care and social assistance (NAICS=62)	0.052 (5.81)***	0.128 (10.30)***	—
Arts, entertainment and recreation (NAICS=71)	0.002 (0.11)	0.070 (2.30)**	—
Accommodation and food services (NAICS=72)	-0.012 (1.40)	0.057 (4.54)***	—
Other services (except public administration) (NAICS=81)	-0.094 (2.85)***	-0.037 (1.20)	—
Share ownership not available	-0.087 (15.87)***	-0.270 (29.90)***	-0.206 (28.41)***
Option value missing (set equal to zero)	-0.064 (11.47)***	-0.242 (24.25)***	-0.240 (32.52)***
Constant	—	—	-0.289 (11.12)***

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

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