Relative Weights on Performance Measures in a Principal-Agent Model with Moral Hazard and Adverse Selection

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ABSTRACT

This paper examines the role of multiple measures of performance in a principal-agent model incorporating both moral hazard and adverse selection. The outcome of interest to the principal depends stochastically on the agent's unobservable ability and effort, while the principal implements a contract contingent on two noisy measures of the outcome. There are three main findings. First, the weights assigned the performance measures are reduced in the presence of adverse selection because the informational rent paid to the agent lowers the return to the principal of hiring the agent, but it does not affect how informative one signal is relative to another. Second, the weights assigned the signals are decreasing in the sensitivity of performance to ability. Third, a signal is assigned more weight if and only if it is more precise and sensitive to the agent's effort; thus, the Banker and Datar (1989) result is robust to the introduction of adverse selection. An empirical test of the model is provided in the context of the CEO pay-for-performance sensitivity and the investment opportunities set (IOS) of the firms they manage. If high IOS firms are more ability-intensive, the model predicts the weights on the performance measures are decreasing in IOS. We examine a sample of 12,221 firm-year observations for 1,411 firms spanning the period 1992-2006 obtained from ExecuComp, CRSP, and Compustat. In agreement with the model, we find that CEO compensation is less sensitive to accounting and stock returns in high IOS firms.

Keywords: Adverse selection; moral hazard; pay-for-performance sensitivity; investment opportunities.

I. INTRODUCTION

Agency theory posits that there are two reasons why executive compensation should be made contingent on performance measures. First, there is the moral hazard problem, which arises because managerial effort is unobservable (Jensen and Meckling, 1976; Holmstrom, 1979; Holmstrom and Milgrom, 1987). Under the premise that performance measures are informative signals of effort, the principal designs the agent's compensation to be contingent on such measures so as to better align the agent's interests with those of the principal, and thereby elicit the desired level of managerial effort. Second, there is the adverse selection problem, which arises because managerial ability is unobservable (Darrough and Melumad, 1995; Harris and Raviv, 1978; Rothschild and Stiglitz, 1976; Spence, 1973; Salop and Salop, 1976; Wilson, 1977). To ensure the agent has the incentive to truthfully reveal his ability, the principal designs the agent's compensation to be contingent on performance measures so as to enable screening (or sorting) across agents of heterogeneous ability. Both sources of asymmetric information suggest that pay should increase with performance measures, as has long been postulated (Larcker, 1983; Murphy, 1985; Sloan 1993) and on which there is extensive evidence (Healy, 1985; Lambert and Larcker, 1987; Sloan, 1993; Bushman et al., 1995, 1996; Ittner et al., 1997).

However, in studying the weights that should be placed on performance measures in executive compensation, the theoretical literature has focused almost exclusively on moral hazard, not taking into account adverse selection. In a model with one unobservable action and two noisy signals of the outcome of interest to the principal, Banker and Datar (1989) show that a signal should be assigned more weight if and only if it is more informative. In models having multiple actions and signals of the outcome, Feltham and Xie (1994) and Datar et al. (2001) focus on the allocation of effort across actions and, in assigning weights to the performance measures, the tradeoffs between (a) the congruity between the agent's overall compensation and the outcome of interest to the principal, and (b) the precision of the signal. Bushman and Indjejikian (1993) and Feltham and Wu (2000) examine how performance measures, the compensation contract, and asset pricing relate to one another in the presence of moral hazard. Finally, Dutta (2008) has one unobservable action and unobservable ability (thereby having both moral hazard and adverse selection), but there are no noisy signals of the outcome, so the principal contracts directly on the outcome.

We extend the model in Banker and Datar (1989) by introducing adverse selection. Our aim is twofold: to derive the role of managerial ability in determining the optimal weights placed on performance measures; and to assess whether the Banker and Datar results are also applicable in a framework that includes both moral hazard and adverse selection. The model is constructed as follows. A risk-averse agent endowed with an unobservable ability exerts unobservable effort on behalf of a risk-neutral principal. Managerial effort and ability stochastically generate an outcome of interest to the principal that may not be contracted upon directly. Rather, the principal and agent observe two performance measures, such as accounting and stock returns, that serve as noisy signals of the outcome. We solve for the optimal incentive contract implemented by the principal that resolves both the moral hazard and adverse selection problems; to achieve this, the contract is designed to be contingent upon the two measures of performance.

We have three main findings. First, the weights placed on the performance measures are smaller in the presence of adverse selection as compared to the benchmark case in which there is only moral hazard. The intuition stems from the need to pay more to higher ability agents in order to optimally induce an agent to truthfully reveal his ability. The lowest ability agent earns the reservation utility, while all others earn a premium in excess of the outside option, referred to as informational rent. By contrast, in pure moral hazard models, all agents earn their reservation utility at the optimum. Hence, due to the cost associated with the agent's informational rent, adverse selection reduces the return to the principal from hiring the agent. The principal seeks to counteract this effect by reducing the sensitivity of the agent's compensation to the outcome. Second, the weights placed on the performance measures are decreasing in the sensitivity of the outcome to managerial ability. This result arises because the informational rent of the agent is increasing in the sensitivity of the outcome to ability: the more important is ability in the generation of the outcome, the more valuable is the agent's private information about his ability. Third, the ratio of the weights placed on the performance measures is similar to that in Banker and Datar; that is, even in the presence of adverse selection, a signal is assigned more weight if and only if it is more informative. A signal is more informative if it has a greater precision and/or is more highly correlated with the outcome of interest to the principal. Hence, adverse selection does not affect how informative is one signal relative to another, so it does not affect their relative importance in the optimal compensation mechanism.

To provide an empirical context within which to test our theoretical predictions, we estimate the relationship between the pay-for-performance sensitivity of chief executives and the investment opportunities set (IOS) of the firms they manage. Managerial ability plays a significant role in high IOS firms. High IOS firms involve to a greater degree a sophisticated mix of new product development, product market differentiation strategies, mergers and acquisitions, capacity expansion projects, and brand development (Mason and Merton, 1985). Overall, high IOS firms are typically more complex, technologically advanced, and strategically differentiated (Levy, 1985; Michel and Hambrick, 1992). There are at least three reasons why a CEO's ability in a high IOS firm is particularly important. First, it is difficult to make decisions regarding the allocation of resources when the firm is experiencing an expansion and high growth opportunities. Managers need to select new investment projects and formulate a strategy regarding mergers and acquisitions. They not only evaluate the future cash flows of potential investment projects, but also compare them with alternative projects. Thus, an executive's ability in selecting projects has a significant impact on the long-term profitability of the firm. Second, high IOS firms usually involve a considerable level of R&D activity. It is particularly demanding to manage a large scale R&D department with the aim to develop patents and obtain a competitive advantage in a technology-intensive field. Executives who are creative and have a strong technical background can thus contribute to a greater extent in high IOS firms. Third, high IOS firms often derive their growth by employing a multi-faceted product differentiation strategy so as to expand the span of their markets and gain market share in existing and new product lines. The role of ability in generating revenue increases with the challenge and complexity of managerial tasks.

It follows that adverse selection problems are more severe in high IOS firms. Managerial ability is relatively important in high IOS firms, and to a large extent ability is unobservable, so adverse selection should be incorporated in a formal analysis of executive compensation in high IOS firms. In the context of our analytical model, we postulate that, because high IOS firms are ability-intensive, the sensitivity of the outcome to managerial ability is larger in high IOS firms. In light of the prediction of our analytical model, we hypothesize that executive compensation at high IOS firms is less sensitive to performance measures as managerial ability plays a more important role. We also test the prediction of our model that the weights placed on performance measures are decreasing in their respective variances, a property established in the moral hazard context that we show is preserved in the presence of adverse selection.

Using a sample of 12,221 firm-year observations for 1,411 firms spanning the period 1992-2006 obtained from ExecuComp, CRSP, and Compustat, we regress CEO compensation on IOS, two performance measures (specifically, accounting and stock returns), the interactions of the two performance measures with IOS, the time-series variances of the two performance measures, and the interactions of the variances with IOS. The evidence is generally supportive of our model. CEO compensation is relatively less sensitive to both accounting and stock returns in high IOS firms; and the coefficients on both returns measures are decreasing in their respective variances. Furthermore, the extent to which the pay-for-performance sensitivity is decreasing in IOS is larger for the accounting return compared to the stock return. We obtain the same qualitative results after controlling for operating cash flows and discretionary accruals.

Prior studies on the relationship between executive compensation and IOS have yielded mixed results. Some studies find that higher pay-for-performance sensitivity reflects a greater cost of monitoring an agent's effort when the principal lacks complete and accurate information about the agent's decisions involving investments (Baber et al., 1996; Gaver and Gaver, 1993; Smith and Watts, 1992; Kwon and Yin, 2006). These studies find that executive compensation depends more on the stock return than the accounting return in high IOS firms because a greater weight on the stock return can alleviate managerial myopic behavior. Other studies find that the weight on stock return is smaller for firms with high market to book ratios (Bizjak et al., 1993; Yermack, 1995). Although these findings are inconsistent with one another, they share a similar theoretical foundation by focusing on moral hazard problems, with the exception of Clinch (1991), who recognizes the importance of the adverse selection problem but does not derive specific hypotheses.

The remainder of the paper is organized as follows. Section 2 proposes the analytical model that introduces adverse selection to the framework of Banker and Datar (1989). Section 3 describes the empirical hypotheses, research design, and sample selection for the study examining the impact of IOS on executive compensation. Section 4 presents the empirical results. Section 5 concludes.

II. THE ANALYTICAL MODEL

Agency Theory

Agency problems arise from the separation of ownership and management in modern corporations (Jensen and Meckling, 1976; Fama, 1980). Agents choose the actions that maximize their own interest, despite the fact that agents work on behalf of principals. Agency theory addresses the problems of both moral hazard and adverse selection that arise from information asymmetries between agents and principals. Agency theory posits that incentive contracts can be designed to align the interest of managers and owners (Jensen and Zimmerman, 1985; Eisenhardt, 1989).

According to moral hazard theory, effort-averse agents tend to engage in behavior that sacrifices shareholders' interests. Jensen and Meckling (1976) prescribe that performance measures are signals of the unobservable actions undertaken by agents. Numerous studies argue that performance-based compensation enhances congruence in the goals of agents and principals, motivating executives to work hard so as to improve firm value (Holmstrom, 1979; Banker and Datar, 1989; Bushman and Indjejikian, 1993; Feltham and Xie, 1994; Datar et al., 2001). Holmstrom (1979) developed a moral hazard model in which incentive contracts using performance measures align the interests of principals and agents. Banker and Datar (1989) examine the relative weights that should be assigned noisy signals of the outcome of interest to the principal. The authors find that a signal should be assigned relatively more weight if and only if it is more informative. In multiple-action models of moral hazard, Feltham and Xie (1994) and Datar et al. (2001) extend the results in Banker and Datar (1989) by examining the agent's allocation of effort across multiple actions, so as to determine how this allocation process impacts the relative weights that should be assigned noisy signals of the outcome. Bushman et al. (1995) is a single-action version of Datar et al. (2001). Overall, the implications stemming from moral hazard theory are that pay should increase with financial performance measures (Larcker, 1983; Murphy, 1985; Sloan 1993). Accordingly, there is extensive evidence that executives are rewarded on the basis of different financial performance measures, such as accounting and market measures (e.g., Healy, 1985; Lambert and Larcker, 1987; Sloan, 1993; Bushman et al., 1996; and Ittner et al., 1997).

Another stream of research on executive compensation focuses on adverse selection problems that arise from the premise that the agent's ability is unknown to the principal. Compensation is not attractive to highly capable candidates for a managerial position if they receive similar base salary levels compared to candidates with low managerial talent (Stiglitz, 1977; Lazear, 1986; Darrough and Melumad, 1995). Adverse selection theory examines contracts that take into account different abilities of agents in a variety of settings (Harris and Raviv, 1978; Rothschild and Stiglitz, 1976; Spence, 1973; Salop and Salop, 1976; Wilson, 1977). Managerial compensation is associated with signals that are noisy measures of an individual's ability to manage an organization; such signals include education, experience, and background (Spence, 1973). Rose and Shepard (1997) find that executives are paid more in firms that are heavily diversified because of matching between high-ability CEOs and firms that are difficult to manage. Henderson and Fredrickson (1996) find that executive compensation is positively related to information-processing ability because "the ability to cope with large volumes of diverse information is likely to be both rare and critical to organizational performance."

To summarize, a principal may assign positive weight to noisy signals of the outcome for two reasons. First, there is the moral hazard problem. If the signals are informative, then they enable the principal to estimate the effort exerted by the agent; thus, when the signals are assigned positive weights, they encourage the agent to exert effort. Second, there is the adverse selection problem. In assigning positive weights to the financial performance measures, the principal provides the agent with the incentive to reveal the truth about his hidden ability; in other words, it enables the revelation (or screening) mechanism.

A handful of studies consider both adverse selection and moral hazard problems, but none examines the relative weights that should be assigned financial performance measures. Biglaiser and Mezzetti (1993) consider the problem of two principals competing for an agent, to find that the optimal compensation contract depends on the (hidden) type of the agent and the relative sizes of the principals. In a framework wherein the principal has superior information than the agent, Inderst (2001) finds that flat incentive contracts are optimal when such "reverse" adverse selection problems are more severe. In a model with adverse selection and moral hazard (with one action), Dutta (2008) investigates the competing effects of firm-specific versus general managerial expertise on pay-for-performance sensitivity. Bernardo et al. (2001) examine a model with moral hazard and adverse selection in which the principal makes an endogenous investment in the project. Levine and Hughes (2005) perform a similar analysis. In Dutta, Bernardo et al., and Levine and Hughes, the principal implements a contract that is directly contingent on the outcome of interest to the principal, as opposed to noisy signals of the outcome.

The Analytical Model

We propose a model that introduces adverse selection to the framework of Banker and Datar (1989), so as to examine the role of managerial ability in executive compensation; and determine the relative weights that noisy signals of the outcome should be assigned in the presence of both moral hazard and adverse selection. A risk-neutral principal hires a risk-averse agent to operate his firm. To run the firm, the agent exerts unobservable effort *e*, which may in general represent any action undertaken by the agent on behalf of the principal. The agent is endowed with an unobservable ability $a \in [\underline{a}, \overline{a}]$ that is drawn from the distribution *F*.[1] Thus, the principal faces moral hazard and adverse selection problems. Let $\mu(a) \equiv [1 - F(a)] / f(a)$ denote the inverse of the hazard rate of *F*. An agent with ability *a* that exerts effort *e* incurs the utility cost $C(e) = ce^2 / 2$ and generates the stochastic outcome (also referred to as firm value) $x(e, a)$ that is of interest to the principal. As in Dutta (2008), we impose assumptions that ensure effort is non-negative at the optimum. As in Feltham and Xie (1994), Datar et al. (2001), and Bushman and Indjejikian (1993), the outcome cannot be contracted upon directly (perhaps because it is unobservable to the principal). Instead, the

[1] The ability distribution must have a compact support so that the fundamental theorem of calculus may be applied when solving the principal's mechanism design problem.

principal and agent observe two noisy signals of the outcome that can be contracted upon: $y_1(e,a)$ and $y_2(e,a)$. Firm value and the two signals of firm value have the following multivariate normal distribution:

$$(1)\quad \begin{bmatrix} x(e,a) \\ y_1(e,a) \\ y_2(e,a) \end{bmatrix} \sim N\left\{ \begin{bmatrix} \delta e + \alpha a \\ \theta_1(\delta e + \alpha a) \\ \theta_2(\delta e + \alpha a) \end{bmatrix}, \begin{bmatrix} \sigma_\varepsilon^2 & \theta_1\sigma_\varepsilon^2 & \theta_2\sigma_\varepsilon^2 \\ \theta_1\sigma_\varepsilon^2 & \theta_1^2\sigma_\varepsilon^2 + \sigma_1^2 & \theta_1\theta_2\sigma_\varepsilon^2 \\ \theta_2\sigma_\varepsilon^2 & \theta_1\theta_2\sigma_\varepsilon^2 & \theta_2^2\sigma_\varepsilon^2 + \sigma_2^2 \end{bmatrix} \right\}.$$

As in Dutta (2008), effort and ability are linearly separable in the outcome. In this sense, we are augmenting the standard framework of moral hazard by introducing a role for ability in the generation of the outcome. The parameter $\delta > 0$ measures the sensitivity of the outcome to effort, and $\alpha > 0$ measures the sensitivity of the outcome to ability. The parameter $\theta_i\delta > 0$ measures the sensitivity of signal *i* to effort, and the parameter $\theta_i\alpha > 0$ measures the sensitivity of signal *i* to ability, for $i = 1,2$. The signals of firm value are correlated due to their mutual dependence on the (stochastic) outcome. In contrast to Feltham and Xie (1994) and Datar et al. (2001), we decompose the variance of a signal into two components. The variance term σ_ε^2 measures the volatility of firm value stemming from random shocks that are not attributable to explicit effort and ability inputs from the agent. The variance term $\theta_i^2\sigma_\varepsilon^2$ captures the variability of signal *i* that is attributable to volatility stemming from the outcome, while the variance term σ_i^2 captures the variability of signal *i* that is not attributable to volatility stemming from the outcome, for $i = 1,2$. Therefore, the ratio $\sigma_i^2/(\theta_i^2\sigma_\varepsilon^2 + \sigma_i^2)$ is the proportion of the signal's variation that cannot be explained by the outcome's variation.

The outside opportunity of the agent is *r*, which represents his reservation utility and as such may be interpreted as the (certainty equivalent) income the agent would earn in the next best available employment opportunity. To simplify the mechanism design problem, as is common in the adverse selection literature, we assume the reservation utility is independent of the agent's ability.[2]

The Structure and Timing of the Game

The principal designs a compensation contract contingent on the two signals of firm value that compels the agent to exert the desired level of effort (incentive compatibility), truthfully reveal his ability (truth-telling), and voluntarily sign the contract (individual rationality). By virtue of the revelation principle (Myerson, 1979), the principal may restrict his attention to truthful mechanisms in which the message space is restricted to be the private information possessed by the agent, namely his ability level. As in Dutta (2008), Datar et al. (2001), Holmstrom and Milgrom (1987), and Feltham and Xie (1994), for tractability, we restrict our analysis to linear compensation contracts of the form

(2) $w(a, y_1(e(a),a), y_2(e(a),a)) = \beta_0(a) + \beta_1(a) y_1(e(a),a) + \beta_2(a) y_2(e(a),a)$,

where the coefficient $\beta_0(a)$ represents the fixed component of the agent's compensation, the coefficient $\beta_1(a)$ the sensitivity of the agent's compensation to signal $y_1(e(a),a)$ of the outcome, and the coefficient $\beta_2(a)$ the sensitivity of the agent's compensation to signal $y_2(e(a),a)$ of the outcome.

The timing of the game is as follows. The principal designs the compensation mechanism $w(a, y_1(e(a),a), y_2(e(a),a))$ contingent on the two signals of firm value that satisfies truth-telling, incentive compatibility, and individual rationality. Based on the properties of the mechanism $w(a, y_1(e(a),a), y_2(e(a),a))$, the agent decides what level of effort to exert, what ability level to report to the principal, and whether to enter into the employment contract. At the end of the period, the relationship is complete: the outcome $x(e(a),a)$ and signals $y_1(e(a),a)$ and $y_2(e(a),a)$ of the outcome are generated, and the agent is compensated as specified by the terms in the contract. The following figure illustrates the timing of the game:

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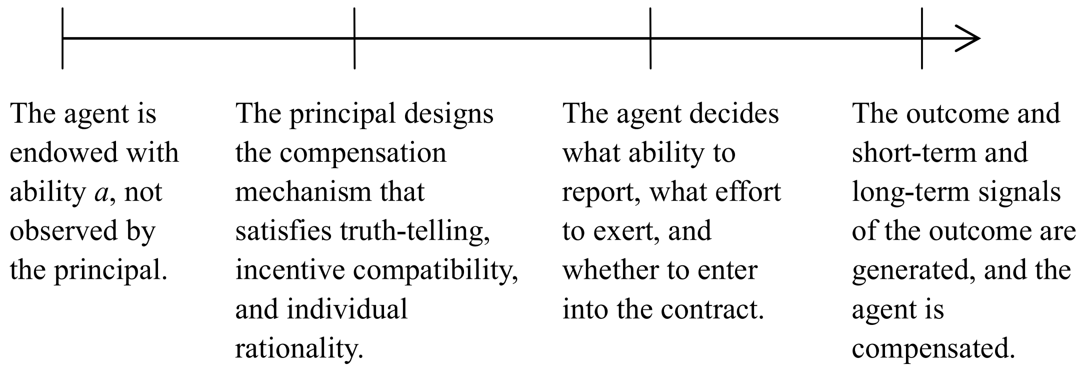
[2] Dutta (2008) studies a principal-agent problem with adverse selection and moral hazard in which the outside option of the agent depends on his ability in a linear fashion.

Figure 1: Timing of the Game



As in Dutta (2008), Datar et al. (2001), and Feltham and Xie (1994), we assume the agent has constant absolute risk aversion (CARA) preferences, such that his utility (conditional on the message being a, i.e. truthful) is

$$\begin{aligned}(3)\quad & U^A(w(a, y_1(e(a), a), y_2(e(a), a)), e(a)) = \\ & -\exp\{-R[w(a, y_1(e(a), a), y_2(e(a), a)) - C(e(a))]\}\end{aligned},$$

where R is the agent's coefficient of absolute risk aversion (CARA). Because the compensation contract is linear and the short-term and long-term signals of the outcome are normally distributed, this enables us to express the agent's expected utility in terms of his certainty equivalent[3]:

$$\begin{aligned}(4)\quad & CE(w(a, y_1(e(a), a), y_2(e(a), a)), e(a)) = E[w(a, y_1(e(a), a), y_2(e(a), a))] \\ & - RVar[w(a, y_1(e(a), a), y_2(e(a), a))]/2 - C(e(a))\end{aligned}.$$

Using (2) and the fact that $E[y_i(e(a), a)] = \theta_i E[x(e(a), a)]$ for $i = 1,2$, we infer the expected income of the agent is

$$\begin{aligned}(5)\quad & E[w(a, y_1(e(a), a), y_2(e(a), a))] = \beta_0(a) + (\beta_1(a)\theta_1 + \beta_2(a)\theta_2)E[x(e(a), a)] \\ & = \beta_0(a) + (\beta_1(a)\theta_1 + \beta_2(a)\theta_2)(\delta e(a) + \alpha a)\end{aligned}.$$

Using (2), we infer the variance of the agent's income is

[3] The certainty equivalent is the income that makes the agent indifferent between earning the certainty equivalent for sure versus facing the uncertainty inherent in the stochastic compensation mechanism.

$$
\begin{aligned}
&Var[w(a, y_1(e(a),a), y_2(e(a),a))] = \beta_1^2(a)Var(y_1(e(a),a)) + \beta_2^2(a)Var(y_2(e(a),a)) \\
(6)\quad &+ 2\beta_1(a)\beta_2(a)Cov(y_1(e(a),a), y_2(e(a),a)) \\
&= \beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2
\end{aligned}
.
$$

The principal seeks to maximize firm value net of the agent's compensation. Thus, the expected payoff of the principal (conditional on the message being a, i.e. truthful) is

$$
(7)\quad
\begin{aligned}
&U^P(w(a, y_1(e(a),a), y_2(e(a),a)), e(a)) = E[x(e(a),a) - w(a, y_1(e(a),a), y_2(e(a),a))] \\
&= (1 - \beta_1(a)\theta_1 - \beta_2(a)\theta_2)(\delta e(a) + \alpha a) - \beta_0(a)
\end{aligned}
.
$$

To ensure the compensation mechanism designed by the principal is optimal, we assume the inverse of the hazard rate is decreasing in ability:

(A1) $\mu_a(a) \le 0$.

This is a common assumption in mechanism design (e.g. Bolton and Dewatripont, 2005; Salanie, 2005; Dutta, 2008). Bagnoli and Bergstrom (2005) show that if a density function f is log-concave, then $\mu_a(a) \le 0$.[4] If a distribution has a log-concave density function, then any truncation of the distribution also has a log-concave density function. The authors provide numerous cases of popular density functions that are log-concave, including the uniform, normal, exponential, logistic, Beta, and Gamma. Therefore, truncated forms of these density functions (i.e. with the support $[\underline{a}, \overline{a}]$) are log-concave, having a decreasing $\mu(a)$ as required by (A1). Finally, to ensure effort is non-negative at the optimum and thereby obtain an interior solution for the optimal compensation mechanism, we assume

(A2) $c\alpha \le \delta^2 f(\underline{a})$.

The Principal's Problem with Moral Hazard

To establish a benchmark, we first solve the problem in which the principal does not observe the exert e exerted by the agent, but does observe the ability a of the agent, such that the principal faces moral hazard, but not adverse selection. The principal's problem is

$$
(8)\quad \max_{\{\beta_0^{MH}(a), \beta_1^{MH}(a), \beta_2^{MH}(a), e(a)\}} E[x(e^{MH}(a),a) - w^{MH}(a, y_1(e^{MH}(a),a), y_2(e^{MH}(a),a))],
$$

---

[4] A density function f is log-concave if $(\ln f(x))'' \le 0$ for all x in the support of f.

subject to the individual rationality constraint of the agent

(9) $CE(w^{MH}(a, y_1(e^{MH}(a), a), y_2(e^{MH}(a), a)), e^{MH}(a)) \geq r$;

and the incentive compatibility constraint of the agent

(10) $e^{MH}(a) = \arg\max_{\hat{e}} CE(w^{MH}(a, y_1(\hat{e}, a), y_2(\hat{e}, a)), \hat{e})$.

The individual rationality constraint (9) requires that the agent voluntarily sign the employment contract. The incentive compatibility constraint (10) requires that the agent finds it optimal to exert the level of effort desired by the principal.

The following lemma describes the solution to the principal's problem with moral hazard.

LEMMA 1: Suppose the principal faces moral hazard. The coefficient on the signal $y_1(e^{MH}(a), a)$ of the outcome is

(11) $$\beta_1^{MH}(a) = \frac{\delta^2 \theta_1 \sigma_2^2}{(\delta^2 + cR\sigma_\varepsilon^2)(\theta_1^2 \sigma_2^2 + \theta_2^2 \sigma_1^2) + cR\sigma_1^2 \sigma_2^2} .$$

The coefficient on the signal $y_2(e^{MH}(a), a)$ of the outcome is

(12) $$\beta_2^{MH}(a) = \frac{\delta^2 \theta_2 \sigma_1^2}{(\delta^2 + cR\sigma_\varepsilon^2)(\theta_1^2 \sigma_2^2 + \theta_2^2 \sigma_1^2) + cR\sigma_1^2 \sigma_2^2} .$$

Proof: Please see the Appendix.

We obtain the usual properties that arise in a standard moral hazard problem (Holmstrom, 1979; Holmstrom and Milgrom, 1987). The coefficients on the two signals of the outcome are decreasing in the agent's cost of exerting effort *c*. A higher cost of exerting effort decreases the role of incentive-based compensation: the more costly it is for the agent to exert effort, the less useful is performance pay in eliciting the desired level of effort. Furthermore, the coefficients on the two signals of the outcome are decreasing in the agent's coefficient of absolute risk aversion *R*. Since the principal is risk neutral, the more risk averse is the agent, optimal risk-sharing requires that the smaller is the extent to which the principal exposes the agent to risk by making his compensation mechanism less sensitive to (stochastic) performance measures. Finally, at the optimum, all agents earn their outside opportunity *r*.

The following proposition describes the way in which the coefficients on the two signals of the outcome depend on managerial ability.

PROPOSITION 1: Suppose the principal faces moral hazard. The coefficients on the two signals of the outcome $\{\beta_1^{MH}(a), \beta_2^{MH}(a)\}$ are independent of the agent's ability *a* and the sensitivity of the outcome to ability α.

Proof: Follows directly by inspecting (11) and (12).

The coefficients on the signals of the outcome do not depend on the agent's ability since effort and ability are linearly separable in the outcome, which is a common assumption in the agency literature (Dutta, 2008). That is, the marginal return on effort does not depend on the agent's ability. As a result, all agents, irrespective of their (observable) ability, face the same incentives to exert effort; and the coefficients on the two signals of the outcome do not depend on the sensitivity of the outcome to ability α.

The following proposition calculates the Banker and Datar (1989) ratio of the coefficients on the signals.

PROPOSITION 2: Suppose the principal faces moral hazard. The ratio of the coefficients on the two signals of the outcome is

$$(13)\quad \frac{\beta_1^{MH}(a)}{\beta_2^{MH}(a)} = \frac{\theta_1 \sigma_2^2}{\theta_2 \sigma_1^2}.$$

Proof: Follows directly by dividing (11) and (12).

The ratio of the coefficients on the signals of the outcome reflects the Banker and Datar (1989) result that a signal is assigned greater weight if and only if it is more informative. Signal y_i is more informative than signal y_j if it is more precise (i.e. $\sigma_j^2 > \sigma_i^2$), and/or if it is more highly correlated with the outcome (i.e. $\theta_i > \theta_j$).

The Principal's Problem with Moral Hazard and Adverse Selection

The principal's mechanism design problem is to maximize his expected payoff

$$(14) \quad \max_{\{\beta_0(a),\beta_1(a),\beta_2(a),e(a)\}} \int_{\underline{a}}^{\overline{a}} E[x(e(a),a) - w(a, y_1(e(a),a), y_2(e(a),a))]dF(a),$$

subject to the individual rationality constraint of the agent

$$(15) \quad CE(w(a, y_1(e(a),a), y_2(e(a),a)), e(a)) \geq r \quad \text{for all} \quad a \in [\underline{a}, \overline{a}];$$

the incentive compatibility constraint of the agent

$$(16) \quad e(a) = \arg\max_{\hat{e}} CE(w(a, y_1(\hat{e},a), y_2(\hat{e},a)), \hat{e}) \quad \text{for all} \quad a \in [\underline{a}, \overline{a}];$$

and the truth-telling constraint of the agent

$$(17) \quad CE(w(a, y_1(e(a),a), y_2(e(a),a)), e(a)) \geq CE(w(\tilde{a}, y_1(e(\tilde{a}),a), y_2(e(\tilde{a}),a)), e(\tilde{a}))$$

for all $a, \tilde{a} \in [\underline{a}, \overline{a}]$. There are two differences between the principal's problem with moral hazard and adverse selection (14) versus the principal's problem with pure moral hazard (8). First, because the principal does not observe the agent's ability prior to the establishment of the agency relationship, the principal maximizes his expected payoff averaged over the entire ability distribution *F*. Second, so as to resolve the adverse selection problem, the truth-telling constraint (17) is added, which requires that, for any pair of ability levels *a* and $\tilde{a}$, an agent with ability *a* is at least as well off by announcing *a* than any other ability level $\tilde{a}$.

The following lemma describes the solution to the mechanism design problem.

LEMMA 2: Assume (A1)-(A2). Suppose the principal faces moral hazard and adverse selection. The coefficient on the signal $y_1(e(a),a)$ of the outcome is

$$(18) \quad \beta_1(a) = \frac{(\delta^2 - \mu(a)c\alpha)\theta_1\sigma_2^2}{(\delta^2 + cR\sigma_\varepsilon^2)(\theta_1^2\sigma_2^2 + \theta_2^2\sigma_1^2) + cR\sigma_1^2\sigma_2^2}.$$

The coefficient on the signal $y_2(e(a),a)$ of the outcome is

$$(19) \quad \beta_2(a) = \frac{(\delta^2 - \mu(a)c\alpha)\theta_2\sigma_1^2}{(\delta^2 + cR\sigma_\varepsilon^2)(\theta_1^2\sigma_2^2 + \theta_2^2\sigma_1^2) + cR\sigma_1^2\sigma_2^2}.$$

Proof: Please see the Appendix.

A number of properties stemming moral hazard theory are preserved (Banker and Datar, 1989; Holmstrom and Milgrom, 1987). The coefficients on both signals of the outcome are decreasing in their respective variances: because the agent is risk averse and the principal is risk neutral, optimal risk-sharing requires that the more volatile are the performance measures, the less sensitive should be the agent's compensation to the performance measures. Furthermore, the coefficients on the two signals of the outcome are decreasing in the agent's coefficient of absolute risk aversion *R* and the agent's cost of exerting effort *c*.

The following proposition describes the novel properties of the coefficients on the two signals of the outcome.

PROPOSITION 3: Assume (A1)-(A2).

1. The coefficients on the two signals of the outcome are smaller when the principal faces adverse selection, i.e. $\beta_i^{MH}(a) > \beta_i(a)$ for all $a \in [\underline{a}, \overline{a}]$ and $i = 1,2$.
2. When the principal faces both moral hazard and adverse selection, the coefficients on the two signals of the outcome $\{\beta_1(a), \beta_2(a)\}$ are increasing in the agent's ability a and decreasing in the sensitivity of the outcome to ability α.

Proof: Please see the Appendix.

The sensitivity of the agent's compensation to the outcome is $\beta_1(a)\theta_1 + \beta_2(a)\theta_2$. Applying (18) and (19), it is given by

$$(20)\quad \beta_1(a)\theta_1 + \beta_2(a)\theta_2 = \frac{\delta^2 - \mu(a)c\alpha}{\delta^2 + cR[\sigma_\varepsilon^2 + \sigma_1^2\sigma_2^2(\theta_1^2\sigma_2^2 + \theta_2^2\sigma_1^2)^{-1}]}.$$

The degree of incongruity is $(1 - \beta_1(a)\theta_1 - \beta_2(a)\theta_2)^2$, which measures the extent to which the interests of the agent are misaligned with those of the principal (Datar et al., 2001).[5] The principal designs the sensitivity of the agent's compensation to each signal so as to balance three factors. First, there is incentive compatibility. The larger is the degree of incongruity,

[5] Unlike Datar et al. (2001), even if the agent is risk neutral, the principal's mechanism design problem does not reduce to minimizing the degree of incongruity due to the adverse selection problem.

the greater is the conflict of interest between the agent and principal. By diminishing the degree of incongruity (but not minimizing it), the principal is implementing incentive compatibility with respect to the agent's effort problem, with the aim to resolve the moral hazard problem. Indeed, we show in the proof of Lemma 2 that the effort policy is $e(a)=\delta(\beta_1(a)\theta_1+\beta_2(a)\theta_2)/c$; thus, the greater is $\beta_1(a)\theta_1+\beta_2(a)\theta_2$ (i.e. the smaller is the degree of incongruity), the more effort is exerted by the agent.[6] Second, there is risk-sharing. The principal is risk neutral whereas the agent is risk averse, so the principal must take risk-sharing into consideration. Third, there is revelation (also called screening). We show in the proof of Lemma 2 that, for the revelation mechanism to be implementable (i.e. for screening to be operational such that the agent reveals the truth about his ability), the sensitivity of the agent's compensation to the outcome $\beta_1(a)\theta_1+\beta_2(a)\theta_2$ must be increasing in ability. In other words, to resolve the adverse selection problem, the degree of incongruity must be decreasing in the agent's ability at the optimum; that is, firms operated by high ability agents face less severe conflicts of interest between their principals and agents. To satisfy this condition, we impose assumption (A1), that the inverse of the hazard rate is decreasing in ability, since it is common in agency theory. The implication is that, in accord with standard adverse selection theory, the coefficients on the two signals of the outcome are increasing in the agent's ability a (Bolton and Dewatripont, 2005; Salanie, 2005; Dutta, 2008).

The consideration of incongruity (stemming from the moral hazard problem) tends to make the compensation mechanism more sensitive to the signals, while the risk-sharing consideration tends to make the compensation mechanism less sensitive to the signals. The proposition shows that the consideration of revelation (stemming from the adverse selection problem) tends to make the compensation mechanism *less* sensitive to the signals.

The intuition of this surprising result follows. Let $u^A(a)$ denote the utility an agent of type a gets at the optimum of his program. We show in the proof of Lemma 2 it satisfies

[6] The role of incongruity in contracting was identified by Feltham and Xie (1994).

$u^A(a) = \int_{\underline{a}}^{a} (\beta_1(z)\theta_1 + \beta_2(z)\theta_2)\alpha dz + r$. The difference $u^A(a) - r = \int_{\underline{a}}^{a} (\beta_1(z)\theta_1 + \beta_2(z)\theta_2)\alpha dz$ is the utility the agent earns in excess of the outside opportunity *r*, thus it represents the agent's *informational rent*. Informational rent stems from adverse selection: when the principal solely faces moral hazard, the agent earns the outside option *r* (i.e. the individual rationality constraint binds), thus he earns no informational rent. We find that $u_a^A(a) = (\beta_1(a)\theta_1 + \beta_2(a)\theta_2)\alpha > 0$: higher ability agents earn greater utility (while agents with the lowest ability earn the reservation utility *r*). We infer that the greater is the ability of an agent, the more informational rent he earns, i.e. the more he benefits from his private information. If an agent with ability *a* claims he has the ability $\tilde{a} < a$, then he earns more utility than a truthful agent with ability $\tilde{a}$. The capability of high ability agents to "hide behind" low ability agents provides them informational rent. This rent is the price the principal must pay for high ability agents to reveal their information, which is consistent with Salanie (2005, p. 34). It follows that the higher is the ability of an agent, the more agents there are of lower ability for the agent to hide behind. Adverse selection thereby reduces the payoff of the principal due to the informational cost associated with the agent's informational rent. Consequently, the return to the principal of hiring the agent is reduced in the presence of adverse selection. To counteract this effect, the principal increases the sensitivity of his payoff to the outcome, and thereby correspondingly reduces the sensitivity of the agent's compensation to the outcome.

This result has two implications. First, because the principal designs the compensation contract of the agent to be less sensitive to the outcome in the presence of adverse selection, the effort exerted by the agent is accordingly reduced. Effort is increasing in managerial ability in the presence of adverse selection, while all agents exert the same level of effort in the absence of adverse selection. Nevertheless, all agents exert more effort in the absence of adverse selection. Second, the coefficients on the two signals of the outcome $\{\beta_1(a), \beta_2(a)\}$ are decreasing in the sensitivity of the outcome to ability α. The informational rent of an agent $u^A(a) - r$ is increasing in α: the greater is the role of the agent's private information in the generation of the outcome, the more the agent must be compensated for being privy to that information. Therefore, to reduce the informational cost associated with the adverse selection problem, the principal increases the sensitivity of his payoff to the outcome (and thereby diminishes the weights assigned the two signals of the outcome in the agent's compensation) in response to an increase in α.

To further compare our model to the benchmark case with pure moral hazard, the following proposition calculates the ratio of the coefficients on the two signals of the outcome.

PROPOSITION 4: Assume (A1)-(A2). The ratio of the coefficients on the two signals of the outcome remains the same when the principal faces adverse selection:

(21) $$\frac{\beta_1(a)}{\beta_2(a)} = \frac{\beta_1^{MH}(a)}{\beta_2^{MH}(a)} = \frac{\theta_1\sigma_2^2}{\theta_2\sigma_1^2}.$$

Proof: Follows directly by dividing (18) and (19).

The proposition demonstrates that the Banker and Datar (1989) result is robust to the introduction of adverse selection. Even in the presence of adverse selection, a signal is assigned greater weight if and only if it is more informative. While adverse selection reduces the sensitivity of the agent's compensation to both signals, it preserves the relationship between the two. A signal is more informative if it has a greater precision and/or is more highly correlated with the outcome of interest to the principal. It follows that adverse selection does not fundamentally affect how informative is one signal relative to another, so it does not affect their relative importance in the optimal compensation mechanism. Nevertheless, adverse selection does reduce their absolute importance in compensation.

III. INVESTMENT OPPORTUNITIES IN EXECUTIVE COMPENSATION

Empirical Hypotheses

The impact of investment opportunities (IOS) on executive compensation provides an appropriate empirical context within which to interpret the predictions of our analytical model. We draw attention to the influence of IOS on incentive contracts brought about by the role of managerial ability. High IOS firms require high ability CEOs to manage them. IOS includes capacity expansion projects, new product introductions, firm acquisitions, and brand development (Mason and Merton, 1985). High IOS businesses invest to a greater degree with the aim to create product differentiation, customer loyalty, and patents (Christie, 1989; Chung and Charoenwong, 1991). Firms with high IOS are those that exhibit high market-to-book ratio, which is often a sign that investors expect superior prospects. Since high IOS firms tend to explore new projects, products, customers, and markets to expand rapidly and aggressively, the nature and magnitude of their CEOs' responsibilities are more complex and challenging.

There are at least three reasons why a CEO's ability in a high IOS firm is relatively important. First, high IOS firms demand of their CEOs a substantial ability at formulating and implementing corporate strategy. Product differentiation strategy is commonly employed by high IOS firms to expand markets and gain market share. As corporate strategy becomes driven by product differentiation, CEOs become concerned with an increasingly complex process of strategic implementation. For example, they need to investigate customer adoption of new technologies so as to avoid the failure of new products. Furthermore, the market environment of high IOS firms may be more dynamic and uncertain, having a short product life cycle. Customer loyalty is more tenuous in response to the frequent release of new products from competitiors.

Second, CEOs manage long-horizon innovative activity in high IOS firms (Nelson and Winter, 1977; Bange and DeBondt, 1998; Pisano, 1989). Involvement in scientific discovery and invention increases the difficulty of planning and coordinating activities between R&D and other departments, such as marketing (Lawrence and Lorsch, 1967). Some qualities of CEOs, such as creativity and familiarity with the relevant technology, are required for such firms to be profitable in the long-term.

Third, CEOs in high IOS firms face the challenge of allocating resources and finances among new projects. On the one hand, CEOs of high IOS firms must select and manage investment projects rather than supervise existing assets (Smith and Watts, 1982), which boosts the return on managerial ability. On the other hand, it is difficult for executives to search for internal and external financing so as to fund growth in capital expenditures (Nwaeze et al., 2006). Maintaining a healthy cash flow is thereby necessary for high IOS firms to survive and thrive.

Overall, then, high IOS firms are more ability-intensive. We interpret this premise in the context of our analytical model as follows: the higher is the IOS of the firm, the more sensitive is the outcome to managerial ability. Proposition 3 proves that the coefficients on the two signals of the outcome are decreasing in the sensitivity of the outcome to ability. We infer that the analytical model predicts the coefficients on the two signals of the outcome should be decreasing in IOS. To examine this prediction in an empirical setting, it remains to define proxies for the two signals of the outcome.

Accounting and stock returns have commonly been interpreted as noisy signals of the outcome of interest to the principal. Both accounting and stock returns have informational value about executive effort (Lambert and Larker, 1987; Sloan, 1993). Stock prices reflect future profitability, anticipated earnings growth, and actions that are expected to be undertaken by managers, while accounting earnings only reflect the contemporaneous financial situation of the firm and behavior of managers. Market measures cannot be distorted by arbitrary accounting rules (Gjesdal, 1981) and cannot be managed by executives (Healy, 1985). If compensation is only linked to yearly accounting numbers, executives may cut back on long-term investments so as to promote short-term profits (Larcker, 1983). On the other hand, market measures do not capture certain types of effort. Feltham and Xie (1994) show that self-interested managers tend to misallocate their actions among multiple tasks if incentive contracts are only based on signals determined by stock prices. It is necessary to rely on accounting numbers to motivate particular types of actions since financial measures convey information about a subset of the CEO's actions (Bushman and Indjejikian, 1993; Lambert, 1983; Lambert, 2001). Also, making executive compensation contingent on stock prices exposes the executive to the volatility of financial markets and economic fluctuations, while accounting performance measures shield executives from systematic market risk (Sloan, 1993). Therefore, executive compensation is linked to both accounting and stock returns.

Baber et al. (1996) performed the most influential study on the role of IOS in executive compensation. The authors have two hypotheses as to how IOS should impact the sensitivity of compensation to accounting and stock returns. First, the authors hypothesize that executive compensation should be more sensitive to accounting and stock returns in high IOS firms. As motivation, the authors cite Smith and Watts (1992), Gaver and Gaver (1993), and Bizjak et al. (1993), who "argue that the management of investment opportunities is particularly difficult to monitor; and therefore, firms with substantial investment opportunities are more likely to link compensation to indicators of firm performance" (p. 299-300). Based on the predictions of our analytical model with moral hazard and adverse selection, we argue the opposite: the weights assigned accounting and stock returns are decreasing in IOS because high IOS firms are more ability-intensive.

Second, Baber et al. (1996) hypothesize that the weight assigned stock return relative to accounting return should be increasing in IOS. The authors make the following argument. Because stock prices are affected by factors beyond managerial control, accounting return can be more informative with respect to managerial actions (Gjesdal, 1981). Furthermore, because accounting return has a smaller variance, its use as a financial performance measure is more efficient from the perspective of optimal risk-sharing (Sloan, 1993). On the other hand, accounting numbers can be manipulated and distorted (Rosen, 1993; Fisher and McGowan, 1983). By contrast, stock return is less likely to be affected by accounting distortions since it anticipates future cash flows. Overall, then, accounting return is less informative with respect to managerial actions when investment opportunities are a substantial portion of firm value (Smith and Watts, 1992; Gaver and Gaver, 1993; Skinner, 1993). Thus, Baber et al. (1996) argue that in high IOS firms, greater reliance on market-based compensation is expected. The predictions of our analytical model are in agreement with the intuition underlying the second hypothesis of Baber et al. (1996). We showed that even in the presence of adverse selection, the Banker and Datar (1989) result holds that a signal should be assigned greater weight if and only if it is more informative (Proposition 4). Baber et al. (1996) expect that the variance of stock return exceeds that of accounting return, and that the variance of accounting return is increasing in IOS more rapidly than that of stock return. Under this premise, our analytical model predicts that, indeed, the weight assigned stock return relative to accounting return should be increasing in IOS.

Yermack (1995) and Kwon and Yin (2006) also hypothesize that pay-for-performance sensitivity (especially the weight on stock return) is increasing in IOS. The authors argue that performance-based compensation helps mitigate moral hazard problems when executive behavior is difficult to monitor in high IOS firms (Baber et al., 1996; Gaver and Gaver, 1993; Smith and Watts, 1992). Since executives have private information regarding investment projects, decisions regarding investments in new projects are less observable than those involving the management of existing assets (Gaver and Gaver, 1993; Clinch, 1991). Consistent with their expectation, Baber et al. (1996) find that the weight on the stock return increases with IOS, and that the weights on accounting return for high IOS firms do not differ much from those of low IOS firms. Kwon and Yin (2006) and Clinch (1991) find that the grants of stock options are greater in high-tech and R&D-intensive firms, respectively. Relatively more weight is placed on stock return compared to accounting return so that managers focus more on long-term as opposed to short-term performance. However, Yermack (1995) documents that companies with greater growth opportunities (market-to-book ratio) use less stock-based compensation. Yermack's finding is inconsistent with his prediction that companies with valuable growth opportunities should pay more stock options to reduce the agency costs arising from asymmetric information between managers and shareholders. Yermack draws upon a similar argument to that in Baber et al. (1996) and Gaver and Gaver (1993).

In disagreement with the above studies, Bizjak et al. (1993) expect a negative relationship between pay-for-performance sensitivity and IOS. The authors find that the weights on stock return are negatively associated with R&D activity and market-to-book ratios because compensation including long-term stock return could reduce agency costs arising from high information asymmetries between managers and shareholders. The authors state: "We illustrate how an overemphasis on current stock price can induce managers with superior information to manipulate the market's expectations by making observable, though suboptimal, investment choices." Clinch (1991) documents that the weights on stock and accounting returns increase with R&D expenditures, but the weight on RET relative to ROE decreases with R&D expenditures.[7] Clinch argues that "whether the relation reflects a decreasing informativeness of RET relative to ROE in a moral hazard setting, or a combination of factors in an adverse selection model, cannot be determined." Clinch

[7] IOS factor is highly correlated with R&D to assets ratio and market to book ratio (see Table 3).

advances the usage of adverse selection theory to explain the change in the weights on performance measures but does not provide a solution with regards to the design of the optimal contract that considers moral hazard and adverse selection problems simultaneously.

We provide such an analytical model, to find that the weights assigned noisy signals of the outcome (i.e. accounting and stock returns) are decreasing in the sensitivity of the outcome to the agent's ability (Proposition 3). Under the presumption that high IOS firms are more ability-intensive, we infer that the weights assigned accounting and stock returns are decreasing in IOS, leading to our first hypothesis:

Hypothesis 1a: The pay-for-performance sensitivity of executive compensation with respect to accounting return is decreasing in IOS.

Hypothesis 1b: The pay-for-performance sensitivity of executive compensation with respect to stock return is decreasing in IOS.

Moral hazard theory suggests that pay-for-performance sensitivity depends on the informational value a financial performance measure provides with respect to the agent's effort (Holmstrom, 1979; Holmstom and Milgrom, 1987). Banker and Datar (1989) demonstrate that the relative weight assigned a performance measure increases with its precision. The noisier is a performance measure, the less information it conveys about the agent's effort. As argued by Core et al (1999): "Firm risk, both as a measure of the firm's information environment and the risk of its operating environment, is also a potentially important determinant of the level of CEO compensation." Smith and Watts (1992) elaborate: "If the principal cannot observe the agents' actions, the optimal contract gives the agent a share in the outcome of his actions. That contract provides an incentive to expend effort to achieve the principal's objective, thus justify the increased compensation of the agent for bearing the additional risk." Consistent with moral hazard theory, a number of empirical studies document that the relative weights on accounting earnings and stock returns are negatively associated with their relative variances (Lambert and Larcker, 1987; Sloan, 1993; Bushman et al., 1996).

Our analytical model extends these theories by combining moral hazard and adverse selection problems, to find that the Banker and Datar (1989) precision result holds even in the presence of adverse selection; that is, the coefficients on both noisy signals of the outcome are decreasing in their respective variances. Interpreting the signals as accounting and stock returns, we obtain our second hypothesis:

Hypothesis 2a: The pay-for-performance sensitivity of executive compensation with respect to accounting return is decreasing in the variance of accounting return.

Hypothesis 2b: The pay-for-performance sensitivity of executive compensation with respect to stock return is decreasing in the variance of stock return.

Estimation Models

To test our hypotheses, we estimate the following OLS models:

$$\begin{aligned}(22)\quad & Ln(TOTALPAY_{i,t}) = \beta_0 + \beta_1 IOS_{i,t} + \beta_2 RET_{i,t} + \beta_3 RET_{i,t} * IOS_{i,t} + \beta_4 ROE_{i,t} + \beta_5 ROE_{i,t} * IOS_{i,t} \\ & + \beta_6 REG_{i,t} + \beta_7 Ln(TA)_{i,t-1} + \varepsilon_{i,t}\ ;\end{aligned}$$

$$\begin{aligned}(23)\quad & Ln(TOTALPAY_{i,t}) = \beta_0 + \beta_1 IOS + \beta_2 RET_{i,t} + \beta_3 RET_{i,t} * IOS_{i,t} + \beta_4 RET_{i,t} * Noise\_RET_{i,t} + \beta_5 ROE_{i,t} \\ & + \beta_6 ROE_{i,t} * IOS_{i,t} + \beta_7 ROE_{i,t} * Noise\_ROE_{i,t} + \beta_8 Noise\_RET_{i,t} + \beta_9 Noise\_ROE_{i,t} + \beta_{10} REG_{i,t} \\ & + \beta_{11} Ln(TA)_{i,t-1} + \varepsilon_{i,t}\ ;\end{aligned}$$

$$\begin{aligned}(24)\quad & Ln(TOTALPAY_{i,t}) = \beta_0 + \beta_1 IOS_{i,t} + \beta_2 RET_{i,t} + \beta_3 RET_{i,t} * IOS_{i,t} + \beta_4 RET_{i,t} * Noise\_RET_{i,t} \\ & + \beta_5 ROE_{i,t} + \beta_6 ROE_{i,t} * IOS_{i,t} + \beta_6 ROE_{i,t} * Noise\_ROE_{i,t} + \beta_7 Noise\_RET_{i,t} \\ & + \beta_8 Noise\_ROE_{i,t} + \beta_9 Ln(TA)_{i,t-1} + \beta_{10} REG_{i,t} + \beta_{11} CFOA_{i,t} + \beta_{12} DA_{i,t} + \varepsilon_{i,t}\ ,\end{aligned}$$

where the subscript t refers to the year and the subscript i refers to the firm. Table 1 lists the definitions of the variable names. We conduct year-by-year regressions to estimate the mean coefficients and Fama-MacBeth t-statistics. By performing year-by-year regressions, we avoid serial correlation problems. Following prior studies (Murphy, 1985; Core et al., 1999; Gaver and Gaver, 1993; Boschen et al., 2003; Duru et al., 2002), the dependent variable is the log of CEO total compensation since the log transformation aids in diminishing the skewness of the compensation distribution. TOTALPAY includes the salary, bonus, stock options, restricted stocks, and other long-term incentives. Stock options are valued using the Black-Scholes model. TOTALPAY is converted into 1992 dollars using the consumer price index to adjust for inflation.

The compensation and financial performance measures we obtain for our sample are comparable to those in Kwon and Yin (2006), Bushman et al. (2006), and Baber et al. (1998). Following prior studies (e.g. Lambert and Larker 1987; Sloan 1993), we employ the two financial performance measures that are the most extensively used in empirical studies of executive compensation: the stock return RET and the accounting return ROE. To be consistent with Baber et al. (1996) and Kwon and Yin (2006), we use ROE as the accounting-based financial performance measure, which is highly correlated with return on assets (ROA). As in Baber et al. (1996), we use factor analysis to extract a composite measure of IOS from the market-to-book ratio, investment intensity, geometric mean of annual growth rate of market value of total assets, and R&D-to-assets ratio. As in prior studies (Lambert and Larcker, 1987; Yermack, 1995; Bushman et al., 2006), we employ the time-series variances of RET and ROE to measure the noise levels of the two performance measures. To alleviate the skewness of the variance distributions and outlier problems, we utilize the fractional rank of the time-series variances of RET and ROE, which are labeled Noise_RET and Noise_ROE, respectively. The variances of financial performances are proxies for firm risk (Aggarwal and Samwick, 1999). We expect positive signs on them because the principal needs to compensate the agent for bearing further risk.

We initially have the following two control variables: whether the industry is regulated and firm size. Pay-for-performance sensitivity is lower for executives in highly regulated industries since limited managerial discretion in these industries diminishes the influence of executives on firm performance (Smith and Watts, 1992; Bushman et al., 2006). A dummy variable, REG, is used to capture the impact on executive compensation of the regulatory environment of the airlines, communications, and utilities industries. Our sample excludes financial industries. In accord with prior studies, we expect to find a negative coefficient for the regulatory industry dummy. We also control for the firm size effect by including the logarithm of total assets, Ln(TA). We expect to find a positive sign for the size effect since prior studies find that executive pay increases with size, which in turn has been attributed to the fact that the tasks performed by CEOs in large firms are more complex (Smith and Watts, 1992; Agarwal, 1981).

We then introduce two more control variables in specification (24). First, executive compensation is associated with cash flow from operating activities because it conveys additional information about managerial effort (Nwaeze et al., 2006). To control for this effect, we use cash flow from operating activities divided by total assets at the end of the fiscal year (CFOA). Second, prior studies show that executives employ income-increasing discretionary accruals to enlarge their earnings-based compensation (Healy, 1985; Balsam, 1998). To estimate discretionary accruals, we use the cross-sectional version of the Jones (1991) model as modified by Kothari et al. (2005):

$$(25) \quad \frac{Accruals_t}{TA_{t-1}} = a_0\left(\frac{1}{TA_{t-1}}\right) + a_1\left(\frac{\Delta Sales_t}{TA_{t-1}}\right) + a_2\left(\frac{PPE_t}{TA_{t-1}}\right) + ROA_t + \varepsilon_t \,,$$

where we have the following: Accruals_t=total accruals, the difference between earnings before extraordinary items and operating cash flow at the end of fiscal year *t*; TA_{t-1} = total assets at the beginning of fiscal year *t*; ΔSale_t= the change in sales revenue in year *t* from year *t-1*; PPE_t= the gross value of property, plant, and equipment at the end of fiscal year *t*; and ROA_t = earnings before extraordinary items divided by total assets at the end of fiscal year *t*. Discretionary accruals (DA) are the residuals from the modified Jones (1991) model in a cross-section by two-digit SIC industry and year. We add ROA as an additional control variable to Jones' model because earnings management behavior is influenced by firm performance (Dechow et al., 1995; Kothari et al., 2005).

We test the two hypotheses drawn from our analytical model. Executive compensation should be relatively less sensitive to financial performance measures when IOS is high; thus, we hypothesize that the interaction terms ROE*IOS and RET*IOS have negative coefficients (Hypotheses 1a and 1b, respectively). Executive compensation should be relatively less sensitive to a financial performance measure when its variability is high; thus, we hypothesize that the interaction terms ROE*Noise_ROE and RET*Noise_RET have negative coefficients (Hypotheses 2a and 2b, respectively).

Sample Data

Spanning the period 1992 to 2006, we obtain CEO compensation from ExecuComp and financial variables from Compustat and CRSP. We delete firms in the financial industry (two-digit SIC code of 60) and those that experienced a change in CEO during our sample period. To calculate the variance of performance measures, we only keep firms with at least five observations during our sample period. We delete all continuous variables at the bottom 1% and top 1% level to mitigate outlier problems. After eliminating companies with missing financial data, our final sample consists of 12,221 firm-year observations (1,411 firms).

Table 2 presents descriptive statistics of executive compensation and key financial variables. Total compensation has a mean and median of \$2,790k and \$1,651k, respectively. The mean and median of Ln(TA) are 7.164 and 7.022, respectively. The mean return on equity (ROE) is 10.6% and the median is 12%. The mean stock return (RET) is 16% and the median is 10.8%. The medians of the variance of ROE (σ^2ROE) and RET (σ^2RET) are 0.006 and 0.128, respectively, which are similar to the noise levels of earnings in Bushman et al. (2006). The mean of REG is 0.111, which indicates that firms in regulatory industries account for 11% of the sample.

Table 3 shows the factor loadings of the IOS components and their descriptive statistics. Following Baber et al. (1996), we utilize the following four components of IOS: investment intensity (INVINT), geometric mean annual growth rate of market value of total assets (MVAGR), market-to-book value of total assets (MTBA), and research and development expenditure to total assets (RNDA). All four components have high factor loadings, ranging from 0.613 to 0.759. Total variance explained by the factors is 58.1% and the Cronbach Alpha is 0.628. The factor loadings and descriptive statistics of the four components are similar to those reported in Nwaeze et al. (2006) and Kwon and Yin (2006).

Table 4 presents the Pearson correlation coefficients of our sample. The highest correlation of 0.588 is that between Ln(TA) and Ln(TOTALPAY), indicating that executive compensation is greater in larger firms. The second highest correlation of 0.437 is that between CFOA and ROE, suggesting that cash flows are high in firms with superior book earnings. The correlation between Noise_RET and Noise_ROE is 0.396, showing that the volatility of accounting earnings is positively associated with stock price volatility. The correlation between Noise_RET and Ln(TA) is -0.324, showing that small firms tend to have greater stock price volatility. The correlation between DA and CFOA is -0.313, meaning that firms with high cash flows are less likely to manipulate earnings. All other correlation coefficients are below 0.3.

IV. EMPIRICAL RESULTS

Table 5 presents the results of the Fama-MacBeth year-by-year regressions of total executive compensation. Column I of Table 5 provides the results for the OLS regression of equation (22), which includes only two control variables: total assets and the regulatory industries dummy. We obtain positive significant mean coefficients on RET and ROE. The marginal effect of RET at the mean of IOS is 0.249 (Fama-MacBeth t-statistic 7.68), and the marginal effect of ROE at the mean of IOS is 0.390 (Fama-MacBeth t-statistic 5.44). These results are consistent with prior research (Murphy, 1985; Ittner et al., 1997; Baber et al., 1996), showing that executives are rewarded for superior financial performance (in terms of both accounting earnings and stock market performance measures). The mean coefficient on RET*IOS is insignificant, while the mean coefficient on ROE*IOS is -0.130 (Fama-MacBeth t-statistic -1.937), which is negative and significant, demonstrating that high IOS firms place smaller weights on accounting returns but not necessarily stock returns. Thus, we only provide partial support for our first hypothesis, which predicts decreasing weights on both accounting and stock returns. The mean coefficient on IOS is positive and significant, and the marginal effect of IOS at the means of RET and ROE is 0.234 (Fama-MacBeth t-statistic 2.39). The results indicate that high IOS firms provide greater compensation to their CEOs, which is consistent with prior studies (Smith and Watts, 1992; Gaver and Gaver, 1993). The mean coefficient on REG is -0.425 (Fama-MacBeth t-statistic -14.816), showing that the level of total compensation is lower in regulated industries, as one would expect (Smith and Watts, 1992; Bushman et al., 2006). The mean coefficient on Ln(TA) is 0.338 (Fama-MacBeth t-statistic 29.916), demonstrating that firm size is positively associated with compensation, in accord with prior studies (Smith and Watts, 1992; Agarwal, 1981).

Column II of Table 5 provides the results for the OLS regression of equation (23), wherein the noise levels of the financial performance measures are included. The coefficients on the interaction terms RET*Noise_RET and ROE*Noise_ROE are negative and significant, indicating that the weights placed on financial performance measures decrease with their volatility. These results are consistent with prior studies (Lambert and Larcker, 1987; Sloan, 1993; Bushman et al., 1996) and our second hypothesis. The coefficients on Noise_RET and

Noise_ROE are positive and significant, indicating agents are compensated for high volatility of financial performance measures, i.e. high risk. These results are consistent with Core et al. (1999), Cyert et al. (1997), and Smith and Watts (1992).

Column III of Table 5 provides the results for the OLS regression of equation (24), which extends the empirical model of equation (23) by including cash flow from operating activities and discretionary accruals. The coefficients on the variables of interest are similar to those reported in Column II. The coefficient on DA is negative and marginally significant, implying that executives have insufficient control to increase their compensation by using discretionary accruals. On the other hand, executives receive less pay with larger discretionary accruals, which may lessen the quality of reported earnings. The coefficient on CFOA is positive and marginally significant, suggesting that cash flows have a positive effect on executive compensation after controlling for the moderating effects of IOS and the noise levels of the financial performance measures. This is consistent with the findings in prior studies relating to the positive relation between compensation and cash flows (Nwaeze et al., 2006; Natarajan 1996).

To summarize, in all three specifications (Columns I-III of Table 5), the evidence is supportive of the predictions of the analytical model, with the exception of Hypothesis 1b concerning the interaction of IOS and RET, which yields an insignificant coefficient.

Robustness Checks

There are two prior studies that investigate the moderating impact of IOS on the weights of stock and accounting returns in total executive compensation (Baber et al., 1996; Kwon and Yin, 2006).[8] However, both studies differ from ours in significant ways. The compensation data in Baber et al. (1996) is collected from proxy statements for fiscal years 1992 and 1993, and firms with negative earnings are excluded. Kwon and Yin (2006) selected high-tech firms from CNNFN.com (as of July 20, 2000) and matched low-tech firms as in Francis and Schipper (1999), to finally obtain 872 firm-years from 1993 to 1998. Our sample covers a greater span of firms (12,221 firm-years), a longer time period from 1992 to 2006,

[8] High-tech is highly correlated with IOS. IOS is significantly higher for high-tech firms compared to low-tech firms (Kwon and Yin, 2006).

and does not exclude firms with negative earnings.

Baber et al. (1996) obtain a positive and significant coefficient on the interaction term IOS*RET and an insignificant coefficient on the interaction term IOS*ΔROE in the model with the change of total compensation as the dependent variable. Kwon and Yin (2006) use high-tech (HT) as the moderating variable, and they obtain similar results to those in Baber et al. (1996): a positive and significant coefficient on HT*RET and an insignificant coefficient on HT*ΔROE. We consider a greater number of factors in the determination of pay-for-performance sensitivity, such as the noise levels of financial performance measures. Moreover, we exclude the possibility that pay-for-performance sensitivity decreases with IOS due to the variances of financial performance measures being affected by IOS.

Baber et al. (1996) and Kwon and Yin (2006) employ the change model in their estimation, which we argue is not appropriate in our context. In the change model, the dependent variable is the annual change in the log of total compensation, and as independent variables the authors utilize the annual changes in ROE instead of their levels. In other words, change models assume the autocorrelation coefficients are 1. We calculate in Table 6 the autoregressive coefficients for each firm in our sample by using its residuals from the pooled OLS regression based on the first-order autoregressive model in Park (1967). The null hypothesis that the mean of the autocorrelation coefficients is 1 is rejected at the 0.99 level. The mean and median of the autocorrelation coefficients are 0.351 and 0.396 with a standard deviation of 1.044. Therefore, the change models in Baber et al. (1996) and Kwon and Yin (2006) are not appropriate for our cross-sectional and time-series sample.

In untabulated tests, we find that our results are robust to replacing IOS with R&D intensity or market to book ratio. Moreover, our results are robust to using ROA instead of ROE as the accounting measure of financial performance. If we exclude firms with negative earnings, as in Baber et al. (1996), we also obtain similar results. Finally, in Table 7, we report the results for total cash compensation, which includes salary and bonus. The results for the testing variables are similar to the results obtained with total compensation, and mostly supportive of our hypotheses. Compared to Table 5 results, there are two differences: IOS and the variance of RET are no longer significant.

V. CONCLUSION

This paper extended the analytical model in Banker and Datar (1989) by introducing adverse selection. We found that a noisy signal of the outcome is assigned more weight if and only if it is more informative; thus, the Banker and Datar result is robust to the introduction of adverse selection. We made two more theoretical contributions. First, the presence of adverse selection reduces the pay-for-performance sensitivity of the agent's compensation mechanism. This follows from the fact that, in the presence of adverse selection, the agent earns utility in excess of his outside option, termed informational rent, so as to enable sorting (or screening) across agents of heterogeneous ability; by contrast, in a pure moral hazard model, the agent earns his outside option, thereby accruing no informational rent. The return to the principal of hiring the agent is reduced due to this informational cost, which leads the principal to augment the sensitivity of her payoff to the outcome. Second, the weights assigned noisy signals of the outcome are decreasing in the sensitivity of the outcome to managerial ability. This result also follows from the fact that the agent earns informational rent at the optimum: the more important is the agent's ability in the generation of the outcome, the more valuable is his private information, so the greater is his informational rent.

To provide an empirical context within which to test our theoretical predictions, we investigated the impact of investment opportunities (IOS) on the weights of accounting and stock returns in CEO total compensation. We argued that high IOS firms are more ability-intensive. It is particularly difficult yet crucial to attract and retain highly capable executives in high IOS firms. Indeed, high IOS firms place a heightened sense of importance on managerial ability, as it impacts resource allocation, financing, R&D activity, and corporate strategy. We interpret this premise as implying that the sensitivity of the outcome to managerial ability is increasing in IOS. The model thereby predicts that the weights assigned noisy signals of the outcome (empirically, accounting and stock returns) should be decreasing in IOS. Accordingly, we found that pay-for-performance sensitivity is negatively associated with IOS. We also show that the weights on both financial performance measures decrease with their noise levels, in accord with our model. Finally, we find that total cash compensation is increasing in IOS, which is consistent with Smith and Watts (1992), Gaver and Gaver (1993), and Kwon and Yin (2006).

Our empirical findings provide an explanation as to why prior studies obtain mixed results when examining the relationship between pay-for-performance sensitivity and IOS. Prior studies find that IOS may have a positive or negative effect on pay-for-performance sensitivity (Baber et al., 1996; and Kwon and Yin, 2006; Bizjak et al., 1993; Clinch, 1991). Although such results are inconsistent, most studies predict pay-for-performance sensitivity should be increasing in IOS because larger monitoring costs occur due to the private information possessed by managers concerning investment decisions. Unlike prior studies that focus on the moral hazard problem, our analytical framework demonstrates that optimal incentive contracts must take into account both the agent's unobservable ability and effort, especially when the relative importance of ability is considerable, as occurs in high IOS firms.

Appendix

Proof of Lemma 1:

The agent's effort problem is to maximize the certainty equivalent

$$\begin{aligned}&CE(\hat{e},a)=\beta_0^{MH}(a)+(\beta_1^{MH}(a)\theta_1+\beta_2^{MH}(a)\theta_2)(\delta\hat{e}+\alpha a)\\ \text{(A.1)}\quad &-(R/2)[\beta_1^{MH}(a)^2(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2^{MH}(a)^2(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)+2\beta_1^{MH}(a)\beta_2^{MH}(a)\theta_1\theta_2\sigma_\varepsilon^2]\\ &-c\hat{e}^2/2\end{aligned}$$

with respect to $\hat{e}$, which yields the effort policy

$$\text{(A.2)}\quad e^{MH}(a)=\delta(\beta_1^{MH}(a)\theta_1+\beta_2^{MH}(a)\theta_2)/c\,.$$

The second-order condition (SOC) is satisfied because the effort cost function is convex.

At the optimum, the individual rationality constraint binds, which yields the following expression for the fixed component of the agent's compensation as a function of the effort policy:

$$\begin{aligned}&\beta_0^{MH}(a)=r-(\beta_1^{MH}(a)\theta_1+\beta_2^{MH}(a)\theta_2)(\delta e^{MH}(a)+\alpha a)\\ \text{(A.3)}\quad &+(R/2)[\beta_1^{MH}(a)^2(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2^{MH}(a)^2(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)+2\beta_1^{MH}(a)\beta_2^{MH}(a)\theta_1\theta_2\sigma_\varepsilon^2]\,.\\ &+ce^{MH}(a)^2/2\end{aligned}$$

Applying this expression together with the effort policy to the objective of the principal, the principal's problem becomes

$$\begin{aligned}&\max_{\{\beta_1^{MH}(a),\beta_2^{MH}(a)\}}\ \delta^2(\beta_1^{MH}(a)\theta_1+\beta_2^{MH}(a)\theta_2)/c+\alpha a-\delta^2(\beta_1^{MH}(a)\theta_1+\beta_2^{MH}(a)\theta_2)^2/(2c)\\ \text{(A.4)}\quad &-(R/2)[\beta_1^{MH}(a)^2(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2^{MH}(a)^2(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)+2\beta_1^{MH}(a)\beta_2^{MH}(a)\theta_1\theta_2\sigma_\varepsilon^2]\end{aligned}$$

The first-order conditions of the principal's problem yield the coefficients on the two signals of firm value reported in the main text.

Proof of Lemma 2:

The agent's effort problem is to maximize the certainty equivalent

$$\begin{aligned}&CE(\hat{e},a)=\beta_0(a)+(\beta_1(a)\theta_1+\beta_2(a)\theta_2)(\delta\hat{e}+\alpha a)\\ \text{(A.5)}\quad &-(R/2)[\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)+2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2]-c\hat{e}^2/2\end{aligned}$$

with respect to $\hat{e}$, which yields the effort policy

$$\text{(A.6)}\quad e(a)=\delta(\beta_1(a)\theta_1+\beta_2(a)\theta_2)/c\,.$$

The second-order condition (SOC) is satisfied because the effort cost function is convex.

Let

$$
\text{(A.7)}\quad \begin{aligned}
&U^A(a,\tilde{a}) = \beta_0(\tilde{a}) + (\beta_1(\tilde{a})\theta_1 + \beta_2(\tilde{a})\theta_2)(\delta e(\tilde{a}) + \alpha a) \\
&-(R/2)[\beta_1^2(\tilde{a})(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(\tilde{a})(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(\tilde{a})\beta_2(\tilde{a})\theta_1\theta_2\sigma_\varepsilon^2] - ce(\tilde{a})^2/2
\end{aligned}
$$

denote the utility of an agent of type a who announces his type as $\tilde{a}$, where the effort policy is given by (A.6). The agent announces the type $\tilde{a}$ that maximizes his utility $U^A(a,\tilde{a})$. For the compensation mechanism to be truth-telling (such that equation (17) holds), it must satisfy the FOC and SOC of the agent's message problem. From (A.7), the derivative $\partial U^A(a,\tilde{a})/\partial\tilde{a}$ is given by

$$
\text{(A.8)}\quad \begin{aligned}
&\partial U^A(a,\tilde{a})/\partial\tilde{a} = \beta_0'(\tilde{a}) + (\beta_1'(\tilde{a})\theta_1 + \beta_2'(\tilde{a})\theta_2)(\delta e(\tilde{a}) + \alpha a) \\
&- R[\beta_1'(\tilde{a})(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2'(\tilde{a})(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + (\beta_1'(\tilde{a})\beta_2(\tilde{a}) + \beta_1(\tilde{a})\beta_2'(\tilde{a}))\theta_1\theta_2\sigma_\varepsilon^2]
\end{aligned},
$$

wherein we ignored the contribution of effort by virtue of the FOC of the agent's effort problem (A.6) (i.e. the envelope theorem). The FOC of the agent's message problem must hold evaluated at the truth since the mechanism is truthful at the optimum, thus we have $\partial U^A(a,a)/\partial\tilde{a} = 0$:

$$
\text{(A.9)}\quad \begin{aligned}
&\beta_0'(a) + (\beta_1'(a)\theta_1 + \beta_2'(a)\theta_2)(\delta e(a) + \alpha a) \\
&- R[\beta_1'(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2'(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + (\beta_1'(a)\beta_2(a) + \beta_1(a)\beta_2'(a))\theta_1\theta_2\sigma_\varepsilon^2] \\
&= 0
\end{aligned}.
$$

The derivative $\partial^2 U^A(a,\tilde{a})/\partial\tilde{a}^2$ is given by

$$
\text{(A.10)}\quad \begin{aligned}
&\partial^2 U^A(a,\tilde{a})/\partial\tilde{a}^2 = \beta_0''(\tilde{a}) + (\beta_1''(\tilde{a})\theta_1 + \beta_2''(\tilde{a})\theta_2)(\delta e(\tilde{a}) + \alpha a) \\
&+ (\beta_1'(\tilde{a})\theta_1 + \beta_2'(\tilde{a})\theta_2)\delta e'(\tilde{a}) \\
&- R[\beta_1''(\tilde{a})(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2''(\tilde{a})(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2)] \\
&- R\theta_1\theta_2\sigma_\varepsilon^2[\beta_1''(\tilde{a})\beta_2(\tilde{a}) + 2\beta_1'(\tilde{a})\beta_2'(\tilde{a}) + \beta_1(\tilde{a})\beta_2''(\tilde{a})]
\end{aligned}.
$$

The SOC of the agent's message problem must hold evaluated at the truth since the mechanism is truthful at the optimum, thus we have $\partial^2 U^A(a,a)/\partial\tilde{a}^2 \le 0$:

$$
\text{(A.11)}\quad \begin{aligned}
&\beta_0''(a) + (\beta_1''(a)\theta_1 + \beta_2''(a)\theta_2)(\delta e(a) + \alpha a) \\
&+ (\beta_1'(a)\theta_1 + \beta_2'(a)\theta_2)\delta e'(a) \\
&- R[\beta_1''(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2''(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2)] \\
&- R\theta_1\theta_2\sigma_\varepsilon^2[\beta_1''(a)\beta_2(a) + 2\beta_1'(\tilde{a})\beta_2'(a) + \beta_1(\tilde{a})\beta_2''(a)] \le 0
\end{aligned}.
$$

Differentiate the FOC of the agent's message problem (A.9) with respect to a:

$$
\text{(A.12)}\quad \begin{aligned}
&\beta_0''(a)+(\beta_1''(a)\theta_1+\beta_2''(a)\theta_2)(\delta e(a)+\alpha a)\\
&+(\beta_1'(a)\theta_1+\beta_2'(a)\theta_2)\delta e'(a)+(\beta_1'(a)\theta_1+\beta_2'(a)\theta_2)\alpha\\
&-R[\beta_1''(a)(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2''(a)(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)]\\
&-R\theta_1\theta_2\sigma_\varepsilon^2[\beta_1''(a)\beta_2(a)+2\beta_1'(\tilde{a})\beta_2'(a)+\beta_1(\tilde{a})\beta_2''(a)]=0
\end{aligned}.
$$

Applying (A.12) to the SOC of the agent's message problem (A.11), the SOC becomes

(A.13) $\beta_1'(a)\theta_1+\beta_2'(a)\theta_2\geq 0$.

We infer that the coefficients $\{\beta_1(a),\beta_2(a)\}$ belong to a direct truthful mechanism if they are increasing in ability (i.e. $\beta_i'(a)\geq 0$ for $i=1,2$), in agreement with Salanie (2005, p. 31) and Dutta (2008). Therefore, a sufficient condition for the SOC of the agent's message problem (A.11) to be satisfied is that $\{\beta_1(a),\beta_2(a)\}$ be increasing in ability and the FOC of the agent's message problem (A.9) yields the associated fixed component $\beta_0(a)$ of the agent's compensation mechanism.

We follow the procedure in Myerson (1981) and Salanie (Ch. 2) to solve the principal's mechanism design problem. Let $u^A(a)$ denote the utility an agent of type a gets at the optimum of his program. As the optimal mechanism is truthful, we have

$$
\text{(A.14)}\quad \begin{aligned}
&u^A(a)=U^A(a,a)=\beta_0(a)+(\beta_1(a)\theta_1+\beta_2(a)\theta_2)(\delta e(a)+\alpha a)\\
&-(R/2)[\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2+\sigma_1^2)+\beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2+\sigma_2^2)+2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2]-ce(a)^2/2
\end{aligned}.
$$

Differentiating (A.14) with respect to ability, we find

(A.15) $u_a^A(a)=(\beta_1(a)\theta_1+\beta_2(a)\theta_2)\alpha$,

after having used the FOC of the agent's effort problem (A.6) and the FOC of the agent's message problem (A.9). Integrating (A.15), we obtain the utility of the agent at the optimum:

(A.16) $u^A(a)=\int_{\underline{a}}^{a}(\beta_1(z)\theta_1+\beta_2(z)\theta_2)\alpha dz+r$.

The boundary condition for the integration is given by the individual rationality constraint (15), which binds for the lowest ability agent as in a traditional adverse selection model; thus, the lowest ability agent earns the reservation utility *r*. Combining (A.14) and (A.16), we infer the fixed component of the agent's compensation mechanism as a function of the effort policy and the coefficients on the short-term and long-term signals of firm value $\{\beta_1(a), \beta_2(a)\}$:

$$\text{(A.17)}\quad \begin{aligned} \beta_0(a) &= \int_{\underline{a}}^{a} (\beta_1(z)\theta_1 + \beta_2(z)\theta_2)\alpha dz + r - (\beta_1(a)\theta_1 + \beta_2(a)\theta_2)(\delta e(a) + \alpha a) \\ &+ (R/2)[\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2] + ce(a)^2/2 \end{aligned}.$$

The objective of the principal is $\int_{\underline{a}}^{\bar{a}} [(1 - \beta_1(a)\theta_1 - \beta_2(a)\theta_2)(\delta e(a) + \alpha a) - \beta_0(a)]dF(a)$. Substituting for the fixed component of the agent's compensation mechanism (A.17), the objective of the principal becomes

$$\text{(A.18)}\quad \begin{aligned} &\int_{\underline{a}}^{\bar{a}} [\delta e(a) + \alpha a - ce(a)^2/2 - \int_{\underline{a}}^{a} (\beta_1(z)\theta_1 + \beta_2(z)\theta_2)\alpha dz]dF(a) - r \\ &- (R/2)\int_{\underline{a}}^{\bar{a}} [\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2]dF(a) \end{aligned}.$$

Integrating (A.18) by parts, it becomes

$$\text{(A.19)}\quad \begin{aligned} &\int_{\underline{a}}^{\bar{a}} [\delta e(a) + \alpha a - ce(a)^2/2 - \mu(a)\alpha(\beta_1(a)\theta_1 + \beta_2(a)\theta_2)]dF(a) - r \\ &- (R/2)\int_{\underline{a}}^{\bar{a}} [\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2]dF(a) \end{aligned}$$

Hence, the principal's problem involves maximizing the virtual surplus:

$$\text{(A.20)}\quad \begin{aligned} \max_{\{\beta_1(a),\beta_2(a)\}} \; &\delta e(a) + \alpha a - ce(a)^2/2 - \mu(a)\alpha(\beta_1(a)\theta_1 + \beta_2(a)\theta_2) \\ &- (R/2)[\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2] \end{aligned}.$$

Applying the effort policy $e(a) = \delta(\beta_1(a)\theta_1 + \beta_2(a)\theta_2)/c$, this becomes

$$\text{(A.21)}\quad \begin{aligned} &\max_{\{\beta_1(a),\beta_2(a)\}} \; \delta^2(\beta_1(a)\theta_1 + \beta_2(a)\theta_2)/c + \alpha a - \delta^2(\beta_1(a)\theta_1 + \beta_2(a)\theta_2)^2/(2c) \\ &- \mu(a)\alpha(\beta_1(a)\theta_1 + \beta_2(a)\theta_2) \\ &- (R/2)[\beta_1^2(a)(\theta_1^2\sigma_\varepsilon^2 + \sigma_1^2) + \beta_2^2(a)(\theta_2^2\sigma_\varepsilon^2 + \sigma_2^2) + 2\beta_1(a)\beta_2(a)\theta_1\theta_2\sigma_\varepsilon^2] \end{aligned}.$$

The first-order conditions of the principal's problem (A.21) yield the coefficients on the two signals of firm value reported in the main text. The second-order conditions of the principal's problem are satisfied since the effort cost function is convex. For the mechanism to be optimal, the term $\beta_1(a)\theta_1 + \beta_2(a)\theta_2$ must be increasing in ability so that it may be used as a screening device. A sufficient condition for this to occur is that the inverse of the hazard rate satisfy assumption (A1): $\mu_a(a) \le 0$. Finally, because the effort policy is $e(a) = \delta(\beta_1(a)\theta_1 + \beta_2(a)\theta_2)/c$, to ensure effort is non-negative and thereby obtain an interior solution, we assume $\mu(a)c\alpha \le \delta^2$ for all $a \in [\underline{a}, \overline{a}]$. Given assumption (A1), and using the fact that $\mu(\underline{a}) = 1/f(\underline{a})$, this condition is equivalent to assumption (A2): $c\alpha \le \delta^2 f(\underline{a})$.

Proof of Proposition 3:

We infer that $\beta_i^{MH}(a) > \beta_i(a)$ by comparing (12) versus (18) and (13) versus (19).

We show in the proof of Lemma 2 that the coefficients on the two signals of the outcome $\{\beta_1(a), \beta_2(a)\}$ are increasing in the agent's ability *a*. By inspecting (18) and (19), we infer they are decreasing in the sensitivity of the outcome to ability α.

References

Agarwal, N. C. 1981. Determinants of executive compensation. *Industrial Relations* 20 (1): 36-46.

Aggarwal, R. K. and A. A. Samwick. 1999. The other side of the trade-off: the impact of risk on executive compensation. *The Journal of Political Economy*, 107(1):65-105.

Baber, W. R., S. N. Janankiraman, and S. Kang. 1996. Investment opportunities and the structure of executive compensation. *Journal of Accounting and Economics* 21 (3): 297-318.

Baber, W. R., S. N., Janankiraman, and S. Kang. 1998. Accounting earnings and executive compensation: The role of earnings persistence. *Journal of Accounting and Economics* 25: 169-193.

Balsam, S. 1998. Discretionary accounting choices and CEO compensation. *Contemporary Accounting Research* 15 (3): 229-252.

Bagnoli, M., and T. Bergstrom. 2005. Log-concave probability and its applications. *Economic Theory* 26 (2): 445-69.

Bange, M., and W. DeBondt. 1998. R&D budgets and corporate earnings targets. *Journal of Corporate Finance* 4: 153-184.

Banker, R. and S. Datar. 1989. Sensitivity, precision, and linear aggregation of signals for performance evaluation. *Journal of Accounting Research* 27: 21-39.

Belsley, D.A., E. Kuh, and R.E. Welsch. 1980. *Regression diagnostics*. New York, NY: Wiley.

Bernardo, A. E., H. Cai and J. Luo. 2001. Capital budgeting and compensation with asymmetric information and moral hazard. *Journal of Financial Economics* 61: 311-344.

Bizjak, J., J. Brickley, and J. Cole. 1993. Stock-based incentive compensation and investment behavior. *Journal of Accounting and Economics* 16 (1-3): 349-372.

Boschen, J. F., A. Duru, L. A. Gordon, and K. J. Smith. 2003. Accounting and stock price performance in dynamic CEO compensation arrangements. The Accounting Review 78(1): 143-168.

Biglaiser, G., and C. Mezzetti. 1993. Principals competing for an agent in the presence of adverse selection and moral hazard. *Journal of Economic Theory* 61: 302-330.

Bolton, P. and M. Dewatripont. 2005. *Contract Theory*. Cambridge, MA: MIT Press.

Bushman, R., and R. Indjejikian. 1993. Accounting income, stock price, and managerial compensation. *Journal of Accounting and Economics* 16 (1-3): 3-23.

Bushman, R., R. Indjejikian, and A. Smith, 1995. Aggrerate performance measures in business unit manager compensation: The role of intra-firm interdependencies. *Journal of Accounting Research Supplement*: 101-128.

Bushman, R., R. Indjejikian, and A. Smith, 1996. CEO compensation: the role of individual performance evaluation. *Journal of Accounting and Economics* 21: 161-193.

Bushman, R., E. Engle, and A. Smith. 2006. An analysis of the relation between the stewardship and valuation roles of earnings. *Journal of Accounting Research* 44(1): 53-83.

Christie, A. 1989. Equity risk, the opportunity set, production costs and debt. Working paper. University of Rochester, Rochester, N.Y.

Chung, K., and C. Charoenwong. 1991. Investment options, assets in place, and the risk of stocks. *Financial Management* 20: 21-33.

Clinch, G. 1991. Employee compensation and firms' research and development activity. *Journal of Accounting Research* 29 (1): 59-78.

Collins, D. W., E. L. Maydew, and I. Weiss. 1997. Changes in the value-relevance of earnings and book values over the past forty years. *Journal of Accounting and Economics* 24 (December) 39-67.

Core, J. E., R.W. Holthausen, and D. F. Larcker. 1999. Corporate governance, chief executive officer compensation, and firm performance, Journal of Financial Economics 51: 371-406.

Darrough, M., and N. Melumad. 1995. Divisional versus company-wide focus: The trade-off between allocation of managerial attention and screening of talent. *Journal of Accounting Research* 33 (Supplement): 65-94.

Datar, S., S. Kulp, and R. Lambert. 2001. Balancing performance measures. *Journal of Accounting Research* 39 (1): 75-92.

Dechow, P., A. Hutton, and R. Sloan. 1995. Detecting earnings management. *The Accounting Review* 70 (2): 193-255.

Duru, A., R. J. Iyengar, and A. Thevaranjan. 2002. The shielding of CEO compensation from the effects of strategic expenditure. Contemporary Accounting Research 19(2): 175-193.

Dutta, S. 2008. Managerial expertise, private information, and pay-performance sensitivity. *Management Science* 54 (3): 429-442.

Eisenhardt, K. M. 1989. Agency theory - An assessment and review. *Academy of Management Review* 14 (1): 57-74.

Fama, E. 1980. Agency problems and the theory of the firm. *Journal of Political Economy* 88: 288-307.

Fama, E., and J. MacBeth. 1973. Risk, return, and equilibrium empirical tests. *Journal of Political Economy* 81 (3): 607-636.

Feltham, G., and J. Xie. 1994. Performance measure congruity and diversity in multi-task principal/agent relations. *The Accounting Review* 69 (3): 429-453.

Feltham, G., and M. Wu. 2000. Public reports, information acquisition by investors and management incentives. *Review of Accounting Studies* 5 (2): 155-190.

Francis, J., and K. Schipper. 1999. Have financial statements lost their relevance? Journal of Accounting Research 37(Autumn): 319-352.

Gaver, J,. and K. Gaver. 1993. Additional evidence on the association between the investment opportunity set and corporate financing, dividend, and compensation policies. *Journal of Accounting and Economics* 16: 125-160.

Gjesdal, F. 1981. Accounting for stewardship. *Journal of Accounting Research* 19: 208-231.

Greene, W.H. 1990. *Econometric Analysis.* New York: Macmillan Publishing Company.

Harris, M., and A. Raviv. 1978. Some results on incentive contracts with applications to education and employment, health insurance, and law enforcement. *American Economic Review* 68 (1): 20-30.

Healy, P. 1985. The effect of bonus schemes on accounting decisions. *Journal of Accounting and Economics* 7: 85-107.

Henderson, A. D. and J. W. Fredrickson. 1996. Information-processing demands as a determinant of CEO compensation. *The Academy of Management Journal* 39(3): 575-606.

Holmstrom, B. 1979. Moral hazard and observability. *Bell Journal of Economics* 10: 74-91.

Holmstrom, B. and P. Milgrom. 1987. Aggregation and linearity in the provision of intertemporal incentives. *Econometrica* 55(March): 303-328.

Inderst, R. 2001. Incentive schemes as a signaling device. *Journal of Economic Behavior & Organization* 44: 455-465.

Ittner, C., D. Larcker, and M. Rajan. 1997. The choice of performance measures in annual bonus contracts. *The Accounting Review* 72: 231-255.

Jensen, M., and W. Meckling. 1976. Theory of the firm: managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3: 305-360.

Jensen, M., and J. Zimmerman. 1985. Management compensation and the managerial labor market. *Journal of Accounting and Economics* 7: 3-9.

Jones, J. 1991. Earnings management during import relief investigations. *Journal of Accounting Research* 39 (2): 297-327.

Kothari, S. P., A. Leone, and C. Wasley. 2005. Performance matched discretionary accruals. *Journal of Accounting and Economics* 39 (1): 161-197.

Kwon, S. S., and Q. J. Yin. 2006. Executive compensation, investment opportunities and earnings management: high-tech firms versus low-tech firms. *Journal of Accounting, Auditing, and Finance* 21 (2): 119-148.

Lambert, R. A. 1983. Long-term contracts and moral hazard. *Bell Journal of Economics* 14 (Autumn): 441-452.

Lambert, R., and D. Larcker. 1987. An analysis of the use of accounting and market measures of performance in executive compensation contract. *Journal of Accounting Research* 25 (Supplement): 85-129.

Lambert, R. A. 2001. Contracting theory and accounting. *Journal of Accounting and Economics* 32 (December): 3-87.

Larcker, D. F. 1983. The association between performance plan adoption and corporate capital investment. *Journal of Accounting and Economics* 5: 3-30.

Lawrence, P. R., and J. W. Lorsch. 1967. Differentiation and integration in complex organizations. *Administrative Science Quarterly* 12: 1-47.

Lev, B. and P. Zarowin. 1999. The boundaries of financial reporting and how to extend them. *Journal of Accounting Research* 37(Autumn):353-386.

Lev, B. and T. Sougiannis. 1996. The capitalization, amortization, and value-relevance of R&D. *Journal of Accounting and Economics* 21: 107-138.

Levine, C. B., and J. S. Hughes. 2005. Management compensation and earnings-based covenants as signaling devices in credit markets. *Journal of Corporate Finance* 11: 832-850.

Levy, D. 1985. The transactions cost approach to vertical integration: an empirical examination. *Review of Economics and Statistics* 67: 438-445.

Lewis, T. R., and D. E. Sappington. 2000. Contracting with wealth-constrained entrepreneurs. *International Economic Review* 41 (3): 743-67.

Mason, S.P., and R.C. Merton. 1985. The role of contingent claims analysis in corporate finance, in: *Recent Advance in Corporate Finance*, edited by E.I. Altman, Homewood, IL: Irwin.

Michel, J. G., and D. C. Hambrick. 1992. Diversification posture and top management team characteristics. *Academy of Management Journal* 35: 9-37.

Murphy, K. J. 1985. Corporate performance and management remuneration: an empirical analysis. *Journal of Accounting and Economics* 7: 11-42.

Myerson, R. 1979. Incentive compatibility and the bargaining problem. *Econometrica* 47 (1): 61-73.

Myerson, R. 1981. Optimal auction design. *Mathematics of Operations Research* 6 (1): 58-73.

Natarajan, R. 1996. Stewardship value of earnings components: Additional evidence on the determinants of executive compensation. *The Accounting Review* 71(1): 1-22.

Nelson, R., and S. Winter. 1977. In search of useful theory of innovation. *Research Policy* 6: 36-76.

Nwaeze, E.T., S.M. Yang, and J. Yin. 2006. Accounting information and CEO compensation: the role of cash flow from operations in the presence of earnings. *Contemporary Accounting Research* 23 (1): 227-265.

Park, R.W. 1967. Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *Journal of the American Statistical Association* 62: 500-509.

Pisano, G. 1989. Using equity participation to support change: Evidence from the biotechnology industry. *Journal of Law, Economics and Organization* 5: 109-126.

Rogers, W. 1993. Regression standard errors in clustered sample. In *Stata Technical Bulletin Reprints* 3: 83-94. College Station , TX: SLn(TA)Ln(TA) Press.

Rose, N., and A. Shepard. 1997. Firm diversification and CEO compensation: managerial ability or executive entrenchment? *The RAND Journal of Economics* 28 (3): 489-514

Rothschild, M., and J. Stiglitz. 1976. Equilibrium in competitive insurance markets: an essay on the economics of imperfect information. *Quarterly Journal of Economics* 90 (4): 629-649.

Salanie, B. 2005. *The Economics of Contracts*. Cambridge, MA: MIT Press.

Salop, J., and S. Salop. 1976. Self-selection and turnover in the labor market. *Quarterly Journal of Economics* 90 (4): 619-627.

Skinner, D., and R. Sloan. 2002. Earnings surprise, growth expectations, and stock returns or don't let an earnings torpedo sink your portfolios. *Review of Accounting Studies* 7: 289-312.

Sloan, R. 1993. Accounting earnings and top executive compensation. *Journal of Accounting and Economics* 16(1-3): 55-100.

Smith, C., and R. Watts. 1992. The investment opportunities set and corporate financing, dividend, and compensation policies. *Journal of Financial Economics* 32: 263-292.

Spence, M. 1973. Job market signaling. *Quarterly Journal of Economics* 87: 355-374.

Yermack, D. 1995. Do corporations award CEO stock options effectively. *Journal of Financial Economics* 39 (2-3): 237-269.

White, H. 1980. A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48 (4): 817–838.

Wilson, C. 1977. A model of insurance markets with incomplete information. *Journal of Economic Theory* 16 (2): 167-207.

TABLE 1
Variable definitions

$TOTALPAY_{i,t}$	CEO's total compensation for fiscal year t, including salary bonus, stock option, restricted stock and other long-term incentives.
$IOS_{i,t}$	investment opportunities factor extracted from the market-to-book ratio, investment intensity, geometric mean of annual growth rate of market value of total assets, and R&D-to-asset ratio at the beginning of fiscal year (as calculated in Table 3).
$ROE_{i,t}$	earnings before extraordinary items and discontinued operations (Compustat annual #18) divided by the common equity at the end of fiscal year (Compustat annual #60).
$RET_{i,t}$	stock return to shareholders in the fiscal year.
$Noise\_ROE_i$	fractional rank of time-series variance of ROE for firm i starting from 1992.
$\sigma^2 ROE_i$	time-series variance of ROE for firm i starting from 1992.
$Noise\_RET_i$	fractional rank of time-series variance of RET for firm i starting from 1992.
$\sigma^2 RET_i$	time-series variance of RET for firm i starting from 1992.
$REG_{i,t}$	dummy variable equal to 1 for regulatory industries with the following two-digit SIC codes: 45 (airlines), 48 (communications), and 49 (utilities).
$Ln(TA)_{i,t}$	logarithm of total assets at the end of the fiscal year.
$CFOA_{i,t}$	the cash flow from operating activities divided by total assets at the beginning of fiscal year.
$DA_{i,t}$	discretionary accruals, the residuals from the modified Jones (1991) model.

TABLE 2
Descriptive statistics of total compensation and firm financial characteristics

Variable	Mean	Std Dev	Min	Lower Quartile	Median	Upper Quartile	Max
TOTALPAY ($000)	2790.585	3244.205	191.266	856.925	1651.458	3378.447	24606.95
Ln(TOTAL PAY)	7.455	0.965	5.254	6.753	7.409	8.125	10.111
IOS	-0.129	0.733	-1.104	-0.64	-0.338	0.152	3.544
RET	0.16	0.424	-0.723	-0.106	0.108	0.349	2.339
ROE	0.106	0.151	-1.11	0.062	0.12	0.174	0.674
Noise_RET	0.475	0.272	0.015	0.238	0.464	0.708	0.988
σ^2RET	0.277	0.498	0.014	0.065	0.128	0.282	6.079
Noise_ROE	0.474	0.268	0.013	0.244	0.468	0.695	0.989
σ^2ROE	0.082	0.447	0	0.002	0.006	0.02	9.116
Ln(TA)	7.164	1.433	3.971	6.111	7.022	8.108	10.907
REG	0.111	0.314	0	0	0	0	1
CFOA	0.115	0.084	-0.206	0.065	0.106	0.16	0.417
DA	-0.019	0.119	-1.481	-0.052	-0.012	0.022	0.644

This table reports descriptive statistics of CEO total compensation and firm financial characteristics for 12,221 firm-year observations (1411 firms) from 1992 to 2006. Total compensation is measured in $000. Total compensation is converted into 1992 dollars according to the consumer price index. To alleviate outlier problems, we delete all continuous variables at the bottom 1% and top 1% level.

TABLE 3
Factor loading and descriptive statistics of IOS components

Panel A: Factor loading of IOS components

Variable	IOS factor
INVINT	0.724
MVAGR	0.613
MTBA	0.759
RNDA	0.651
Total Variance Explained	58.1%
Cronbach Alpha	0.628

Variable definitions:

Investment intensity (INVINT):

$$\frac{\sum_{i=t-2}^{i=t}\left[\text{Capital expenditures (\#30)+R\&D expense (\#46) + Acquisitions (\#129)}\right]_i}{\sum_{i=t-2}^{i=t}\text{Depreciation (\#14)}_i}$$

Geometric mean annual growth rate of market value of total assets (MVAGR):

$$\sqrt[n]{\frac{\text{Market value of total assets (\#6 - \#60 + \#199}\times\text{\#25)}_t}{\text{Market value of total assets (\#6 - \#60 + \#199}\times\text{\#25)}_{t-n}}}$$

where n= max[1,2,3], depending on data availability.

Market-to-book value of total assets (MTBA):

$$\frac{\text{Market value of total assets (\#6 - \#60 + \#199}\times\text{\#25)}_t}{\text{Book value of total assets (\#6)}_t}$$

Research and development expenditure to total assets (RNDA):

$$\frac{\text{Research and development expense (\#46)}_t}{\text{Book value of total assets (\#6)}_t}$$

Panel B: Descriptive statistics of IOS components

Variable	Mean	Std Dev	Min	Lower Quartile	Median	Upper Quartile	Max
INVINT	3.388	3.103	0.055	1.599	2.503	4.079	37.655
MVAGR	1.156	0.295	0.31	0.996	1.094	1.257	3.001
MTBA	2.056	1.577	0.545	1.201	1.557	2.282	32.994
RNDA	0.033	0.068	0	0	0	0.037	0.933
IOS factor	0	1	-1.713	-0.637	-0.289	0.299	12.684

This table reports descriptive statistics of IOS factor for 21,255 firm-year observations from 1991 to 2005. We delete all four component variables at the bottom 1% and top 1% level.

TABLE 4
Pearson Correlations

Pearson Correlation Coefficients, N = 12,221
Prob > |r| under H0: Rho=0

	IOS	RET	ROE	Noise_ROE	Noise_RET	Ln(TA)	REG	CFOA	DA
Ln(TOTALPAY)	0.096 <.0001	0.072 <.0001	0.165 <.0001	0.067 <.0001	-0.058 <.0001	**0.588** <.0001	-0.053 <.0001	0.093 <.0001	-0.031 0.001
IOS		-0.046 <.0001	0.111 <.0001	0.087 <.0001	0.267 <.0001	-0.192 <.0001	-0.180 <.0001	0.234 <.0001	-0.083 <.0001
RET			0.182 <.0001	-0.027 0.003	0.098 <.0001	-0.032 0.000	-0.011 0.246	0.172 <.0001	-0.031 0.001
ROE				-0.170 <.0001	-0.190 <.0001	0.115 <.0001	-0.015 0.087	**0.437** <.0001	0.039 <.0001
Noise_ROE					**0.396** <.0001	-0.061 <.0001	-0.178 <.0001	-0.086 <.0001	-0.031 0.001
Noise_RET						**-0.324** <.0001	-0.209 <.0001	-0.010 0.247	-0.051 <.0001
Ln(TA)							0.298 <.0001	-0.070 <.0001	0.028 0.002
REG								-0.099 <.0001	0.053 <.0001
CFOA									**-0.313** <.0001

TABLE 5
Fama-MacBeth regressions of total compensation
(Year-by-year regressions from 1992 to 2006)

	I Ln(TOTALPAY)		II Ln(TOTALPAY)		III Ln(TOTALPAY)	
Variable	Mean Coefficient Estimate	Fama MacBeth t-Statistics	Mean Coefficient Estimate	Fama MacBeth t-Statistics	Mean Coefficient Estimate	Fama MacBeth t-Statistics
Intercept	4.259	115.834	3.857	88.345	3.829	73.837
IOS	0.251***	17.317	0.223***	14.721	0.217***	13.604
RET	0.246***	8.83	0.436***	6.627	0.419***	5.896
RET*IOS	-0.021	-0.804	-0.001	-0.068	-0.004	-0.198
RET* Noise_RET			-0.318***	-3.395	-0.31***	-3.24
ROE	0.373***	6.445	1.969***	9.85	1.806***	11.231
ROE*IOS	-0.13**	-1.937	-0.177***	-2.877	-0.196***	-3.058
ROE* Noise_ROE			-1.914***	-7.563	-1.775***	-8.136
Noise_RET			0.177***	5.372	0.173***	5.351
Noise_ROE			0.46***	12.537	0.447***	13.283
Ln(TA)	0.446***	50.608	0.447***	48.602	0.449***	46.254
REG	-0.635***	-27.191	-0.573***	-24.273	-0.567***	-23.831
CFOA					0.277*	1.47
DA					-0.166*	-1.498
Nobs	12,221		12,221		12,221	
Adjr2	0.45		0.461		0.463	

This table reports the average coefficients from 15-year regressions (1992-2006) and the corresponding Fama-MacBeth t-statistics. White's (1980) heteroscedasticity tests show the models are not in violation of the assumption of homoscedastic errors. *, **, and *** indicate statistical significance levels at 10 percent, 5 percent, and 1 percent respectively, in one-tailed tests.

TABLE 6
Descriptive statistics of the autoregressive coefficients

	Mean	Std Dev	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
ρ	0.351	1.044	-26.86	0.074	0.396	0.695	18.756

ρ is the autoregressive coefficient for 1398 firms using the residuals from the pooled OLS regression of model (22) based on the first-order autoregressive model in Park (1967). 13 firms are excluded from our final sample of 1411 firms because they only have one-year observations. Although we require five-year data to calculate the time-series variances, our final sample does not have five-year observations for each firm because we delete observations with missing variables such as cash flow or discretionary accruals. The null hypothesis of H0: ρ=1 is rejected at t =-23.24, with a degree of freedom 1398. Thus, there is a significant difference between the mean of the autoregressive coefficients in our sample and 1.

TABLE 7
Fama-MacBeth regressions of total cash compensation
(Year-by-year regressions from 1992 to 2006)

	I Ln(CASHPAY)		II Ln(CASHPAY)		III Ln(CASHPAY)	
Variable	Mean Coefficient Estimate	Fama MacBeth t-Statistics	Mean Coefficient Estimate	Fama MacBeth t-Statistics	Mean Coefficient Estimate	Fama MacBeth t-Statistics
Intercept	4.396	137.758	4.207	82.259	4.209	80.688
IOS	0.012	1.077	0.001	0.08	-0.001	-0.183
RET	0.216***	10.024	0.41***	8.253	0.406***	8.147
RET*IOS	0.005	0.193	0.014	0.534	0.013	0.485
RET* Noise_RET			-0.302***	-5.554	-0.299***	-5.539
ROE	0.709***	12.882	2.202***	13.188	2.24***	16.36
ROE*IOS	-0.022**	-1.74	-0.059**	-2.05	-0.037	-1.154
ROE* Noise_ROE			-1.936***	-9.917	-1.952***	-11.703
Noise_RET			0.021	0.892	0.019	0.836
Noise_ROE			0.283***	9.199	0.285***	10
Ln(TA)	0.309***	49.012	0.304***	46.212	0.304***	46.599
REG	-0.467***	-23.23	-0.448***	-20.59	-0.444***	-20.247
CFOA					-0.091	-0.866
DA					-0.184**	-1.905
Nobs	12205		12205		12205	
Adjr2	0.503		0.514		0.515	

This table reports the average coefficients from 15-year regressions (1992-2006) and the corresponding Fama-MacBeth t-statistics. White's (1980) heteroscedasticity tests show the models are not in violation of the assumption of homoscedastic errors. *, **, and *** indicate statistical significance levels at 10 percent, 5 percent, and 1 percent respectively, in one-tailed tests.