An equilibrium model of incentive contracts in the presence of information manipulation

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Abstract

This paper develops an agency model in which stock-based compensation is a double-edged sword, inducing managers to exert productive effort but also to divert valuable firm resources to misrepresent performance. We examine how the potential for manipulation affects the equilibrium level of pay-for-performance sensitivity and derive several new cross-sectional implications that are consistent with recent empirical studies. In addition, we analyze the impact of recent regulatory changes contained in the Sarbanes-Oxley Act of 2002 and show how policies intended to increase firm value by reducing misrepresentation can actually reduce firm value or increase the upward bias in manipulated disclosures.

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1. Introduction

The use of performance-based executive compensation schemes has increased significantly in the last decade (see Murphy, 1999). Although these compensation schemes are clearly intended to align managers’ and shareholders’ interests, there is empirical evidence that stock-based compensation can cause managers to manipulate information in order to increase their compensation at a cost to shareholders.¹ At one legal extreme, Healy (1985), Gaver et al. (1995) and Holthausen et al. (1995) provide evidence that, within the discretion allowed by law, management will “manage” earnings in order to exploit nonlinearities in the relation between earnings and compensation.² At the other extreme, Burns and Kedia (2005), Bergstresser and Philippon (2005), Efendi et al. (2005), Johnson et al. (2005), and Ke (2003) all provide evidence of a positive association between the use of stock-based compensation and fraudulent manipulation of accounting statements while Erickson et al. (2005) find no consistent evidence of such a link.

In addition to the academic evidence cited above, recent corporate scandals (e.g., Enron and WorldCom) have created a widespread perception that the financial and accounting disclosures provided in a corporate culture fixated on stock price performance cannot be trusted.³ To restore confidence, Congress enacted the Sarbanes-Oxley Act of 2002, which increased enforcement and introduced new penalties for fraudulent behavior. The act also requires a firm’s independent audit committee to approve any non-audit services (e.g., management consulting) provided by the accounting firm that produces that firm’s audited financial statements. This provision is intended to reduce the avenues through which management can influence the content of its audited financial statements.

In this paper we develop a simple model of information manipulation and stock-based compensation to examine two main areas of interest. First, we examine how the potential for manipulation affects the characteristics of the equilibrium (linear) stock-based incentive contract. In particular, we investigate how the possibility of manipulation affects the equilibrium level of pay-for-performance sensitivity and derive several cross-sectional predictions, which we relate to the empirical literature on incentive compensation. Second, we use the model to analyze the impact of recent regulatory changes contained in the Sarbanes-Oxley Act of 2002.

Our model is a variation of the principal/agent model in which managers exert unobservable effort and are compensated on the basis of the firm’s stock price. The stock price represents the market’s expectation of future cash flow resulting from the managers’

¹The empirical literature also provides examples of situations in which managers alter real decisions in order to affect their compensation. For example, DeFusco et al. (1990) show that managers take actions to increase stock volatility following option grants. Lewellen et al. (1987) and Lambert et al. (1989) find that managers with options alter the firm’s dividend policy.

²While some forms of earnings management may benefit shareholders (see, for example, Goel and Thakor (2003) for a theoretical argument and Subramanyam (1996) and Barth et al. (1999) for empirical evidence of beneficial earnings management) the papers cited above provide evidence of manipulations that, for a given level of performance, transfer wealth from shareholders to management.

³In a BBC news broadcast, John Hendricks, vice-president at State Street Global Markets, remarked, “You walk into the kitchen and you see a cockroach—you are pretty confident that it is not the only one around. This is the theme that has been hanging over the equity markets in general.” Anais Faraj, an economist at Nomura, stated, “WorldCom is a timely reminder that Enronitis was a systemic problem.” Hilliard Lyons technical analyst Richard Dickson observed, “...you have a perception that corporate America is not being straight with investors, and that the point of accounting is to hide rather than divulge” (see Thwaite and Coggan, 2002).
effort. In standard agency models (e.g., Spence and Zeckhauser, 1971; Ross, 1973; Holmstrom, 1979), the manager can affect the stock price only through the choice of effort. In our model, however, the manager can, using valuable firm resources, engage in unobservable manipulation that upwardly biases disclosed information.

Without the possibility of misrepresentation, the optimal compensation contract is determined by the tradeoff between the benefit of effort and the cost of inducing it (as determined by risk aversion and the disutility of effort). However, when the agent can misrepresent performance, stock-based compensation will act as a double-edged sword, inducing managers to exert effort, which improves firm value, but also inducing managers to inflate or exaggerate performance, which, given the opportunity cost of the firm’s resources, reduces firm value. In addition to the effect of the incentive contract, the amount of manipulation is also affected by the firm’s monitoring environment (we use the phrase “monitoring environment” or “monitoring technology” to represent the collection of parameters that directly affect manipulation: the probability of detection, the penalty if detected, and the cost of hiding manipulative activities that produce a biased disclosure). If manipulation can be perfectly prevented via monitoring, then the incentive contract only needs to control managerial effort, resulting in equilibrium incentive contracts that are the same as those that obtain when manipulation is not possible. However, absent the ability to independently (and perfectly) prevent manipulation via monitoring, the compensation contract will be used to control manipulation, resulting in an equilibrium contract that balances the net benefit of effort with the cost of manipulation.

Given the tradeoff described above, our first set of results concerns the characteristics of the equilibrium contract. We find that the equilibrium pay-for-performance sensitivity is lower than it would be in the absence of the possibility of manipulation. This could shed light on the evidence in Jensen and Murphy (1990) and Murphy (1999) who argue that pay-for-performance sensitivities are too low to be reconciled with standard agency models. We also show how the characteristics of the (imperfect) monitoring environment affect the characteristics of the equilibrium incentive contract. In particular, we show that pay-for-performance sensitivity is increasing in the detection probability (i.e., the likelihood that manipulation will be detected ex post). This result has several empirical implications. For example, firms with more complex business operations, and therefore lower detection probabilities, will have lower pay-for-performance sensitivities. Similarly, if firm size is negatively correlated with the detection probability, then, consistent with empirical evidence in Murphy (1999), larger firms will have lower pay-for-performance sensitivities in equilibrium. Finally, we find that pay-for-performance sensitivity will decrease with the explicit or implicit penalty of being caught manipulating performance. In addition to any legal penalties, if managers are (at a minimum) fired once they are caught, then the penalty will include any private benefits of control and reputational rent they lose when fired. As a result, our model predicts that the pay-for-performance sensitivity will vary across industries according to the size of these benefits. In general, our model implies that the weaker is the firm’s governance system, the lower will be the pay-for-performance sensitivity. This is consistent with evidence in Hartzell and Starks (2003) and Fahlenbrach (2003) who show that pay-for-performance sensitivity increases with various measures of the influence of minority shareholders.

Our second set of results concerns the effect of policy reform on the equilibrium level of manipulation. For this analysis, we interpret the monitoring parameters as policy parameters determined by an external governmental regulatory agency. Here, we find that
there exist situations in which policy changes intended to reduce the extent of misrepresentation (e.g., increases in penalties and detection probabilities) can actually increase the level of information manipulation. When the external regulatory agency increases the expected penalty for manipulation, this reduces the need for the (internal) incentive contract to control manipulation. As a result, the principal, now focusing more on effort, increases the pay-for-performance sensitivity, which increases the manager’s incentive to misrepresent performance. We show that in some cases the effect of the increase in the pay-for-performance sensitivity will dominate the effect of the regulatory reform, leading to a net increase in bias in manipulated disclosures.

Interestingly, in those situations in which an increase in the penalty leads to an increase in manipulation, total welfare also increases (as long as increased penalties carry no additional implementation costs to society). Thus, the level of manipulation is not necessarily negatively correlated with welfare. This occurs because the agent has a multitasking problem (as in Holmstrom and Milgrom, 1991) whereby she is induced, via the contract, to both exert effort and manipulate information. Because the equilibrium level of effort is less than the first best, an increase in effort results in an equilibrium level of effort that is closer to first best, thus generating a welfare improvement.

Our model also provides an analysis of the impact on manipulation of the separation of the provision of certified accounting services from the provision of consulting activities. We model this separation as an increase in the cost of diverting resources in order to induce the third-party monitor to provide biased reports, with the belief that managers will have to take more surreptitious (and therefore more costly) routes to influence the third-party monitor. We show that while this separation unambiguously reduces the extent of manipulation, it also unambiguously lowers the net terminal value of the firm. The intuition is based on the fact that if manipulation and effort remain at a constant level then the separation policy will increase the per-unit cost of manipulation and hence will reduce firm value. In equilibrium, however, this policy will result in a lower level of manipulation but also in a lower level of effort. This occurs because the principal will react to this policy by offering a contract with less stock-based compensation. Due to the envelope theorem, the net reduction in the level of manipulation and in effort exactly offset each other so that the net effect is a lower firm value. Simply put, increasing the cost of hiding such activity leads to less manipulation but also to less effort, resulting in a net decline in firm value.

A key feature of the equilibrium in our model has antecedents in Narayanan (1985), Fudenberg and Tirole (1986), Stein (1989), and Holmstrom (1999). Although these papers consider very different questions—for example, Fudenberg and Tirole (1986) consider predatory monopolist pricing while Holmstrom (1999) considers managerial career concerns—they all develop models that have “signal-jamming” equilibria, whereby an agent takes a costly action that is intended to mislead but actually misleads no one in equilibrium. This also occurs in our model; even though the firm’s value is adjusted to fully correct for the extent of the bias in the manipulated information, the manager still has the incentive to overstate value because otherwise (non-equilibrium behavior) the manager

4Some have argued that the separation policy will lower firm value by eliminating synergies arising from the fact that the consultant gains an intimate understanding of the firm’s operations through the accountant function. While we acknowledge the potential existence (and loss) of this synergy value, we show the existence of an additional source of lost value.
would be perceived by the market as exerting less effort and, accordingly, would receive lower compensation.

In both the above models and ours, information is symmetric (except for the agent’s unobservable choices), allowing market participants to perfectly predict the agent’s equilibrium choices. In contrast, Dye (1988) and Fischer and Verrecchia (2000) consider models in which the equilibrium choice is not perfectly predictable. Dye (1988) studies a model in which the agent is, by assumption, unable to convey relevant private information. In this setting, the revelation principle (Holmstrom, 1979; Myerson, 1979) cannot be utilized and no truthful-revelation equilibrium exists. Dye (1988), however, does not consider external monitoring and public policy issues, as we do. Fischer and Verrecchia (2000) examine a model in which the extent of manipulation is random with respect to investors’ information sets and, as a result, introduces an additional source of valuation risk. While Fischer and Verrecchia (2000) analyze the incentive to manipulate, they do not derive the equilibrium contract or analyze its impact on manipulation; these are two of the main goals of our paper.

Our final set of results concerns the impact of manipulation on incentive pay when some investors cannot perfectly predict the equilibrium amount of bias. Subramanyam (2003) develops a behavioral model in which investors are fooled by manipulations and examines the equilibrium correlation between managerial intelligence, liquidity, and fraudulent behavior.

Under the short-horizon contract and with the existence of naïve investors, the model generates stock price movements that roughly correspond to the boom and bust cycle experienced in the late 1990s (although based on a different mechanism than ours, Povel et al. (2003) also develop a model of boom and bust cycles based on manipulation). A key feature of this period was increased market participation by investors who could be considered less sophisticated and likely to underestimate the extent of manipulation. We show that as the percentage of the market that underestimates the equilibrium extent of manipulation increases, there will also be a concurrent increase in the equilibrium amount of manipulation and in stock-based compensation. Thus, recent increases in market

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5Because these models have no asymmetric information regarding parameters, they do not consider revelation mechanisms (Holmstrom, 1979; Myerson, 1979). This is in contrast to Baron and Besanko (1987) and McAfee and McMillan (1986, 1987), for example, who consider models that combine agency and adverse selection problems.

6Subramanyam (2003) develops a behavioral model in which investors are fooled by manipulations and examines the equilibrium correlation between managerial intelligence, liquidity, and fraudulent behavior.

7According to the Survey of Consumer Finances administered by the Board of Governors and reported in Kennickell et al. (2000) and Kennickell and Starr (1994), direct and indirect ownership of equities increased from 31.6% in 1989 to 48.8% in 1998. Direct ownership increased from 16.2% to 19.2%.
participation by novice investors can explain the greater reliance on incentive compensation in the 1990s and the recent revelations of fraud. One could claim that the increased prevalence of stock-based compensation in the 1990s was due to the recognition of the importance of incentives; our model offers an alternative (but not mutually exclusive) explanation. Finally, the model predicts initially inflated stock prices, followed by a period of price declines either as the inflated claims are not realized or as investors recognize the potential for fraud once some managers are detected by the legal system.

The remainder of the paper is organized as follows. The model is described in Section 2. Section 3 solves for the equilibrium. In Section 4 we analyze the implications of the model. For these first sections, we assume that investors can perfectly predict the equilibrium extent of manipulation. In Section 5 we relax this assumption and analyze the case in which some investors underestimate the extent of manipulation. Finally, Section 6 concludes. All proofs are presented in the Appendix.

2. The model

We model an all-equity firm that operates over three periods. The first period, $t=0$, represents the start-up period in which an entrepreneur (the principal) hires a manager (the agent) to run the firm, specifies the manager's compensation contract, and issues shares. The second period, $t=1$, represents an intermediate stage in which the firm is operating but its ultimate economic value remains uncertain. During this period, a certified third-party monitor provides a (potentially misleading) report $y$ to the market concerning the firm’s ultimate value. Based on this information, the market determines the intermediate stock price $S$. The last period, $t=2$, represents the long run in which the economic value of the firm is realized and fully recognized by the market. The details of each period are described below.

2.1. Effort, terminal value, and information

At the beginning of the initial period, $t=0$, a risk-neutral entrepreneur sets the compensation contract and hires a risk-averse manager. During that period, given the contract, the manager chooses (1) the amount of unobservable effort $e$ to exert and (2) the amount of firm resources or cash flow to divert toward activities that influence the future report of firm value, $\theta$. The manager's $t=0$ effort $e$ affects the gross terminal cash flow at $t=2$ (denoted $V$) according to $V = \beta e + \eta + \varepsilon$, where $\beta > 0$ is a productivity factor, and $\eta \sim N(0, \sigma_\eta^2)$ and $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ are independent random variables. When choosing effort $e$, the manager does not know the realization of either $\eta$ or $\varepsilon$, which are both realized at $t=2$. (The distinction between $\eta$ and $\varepsilon$ will be made clear below.) The parameters $\beta$, $\sigma_\eta^2$, and $\sigma_\varepsilon^2$ are common knowledge.

The value $V$ represents the gross cash flow of the firm. The terminal value of the firm equals this gross cash flow minus any contractual compensation payments made to the manager and any cash flow diverted by the manager in order to bias the report $\theta$. The compensation payments and the amount diverted are discussed further below. We use $V_2$ to denote the net terminal cash flow $V$ minus the compensation payments and the diverted resources.

During the intermediate period, $t=1$, a certified third-party monitor reports to the market the signal $\theta$ of the firm’s gross terminal cash flow. The intermediate state of the firm
is summarized by a “true” signal $y^T$ of the gross terminal cash flow $V$. We assume that the true signal $y^T$ perfectly reveals $\beta e + \eta$ (i.e., $y^T = \beta e + \eta$ and $E[V | y^T] = \theta^T(= \beta e + \eta)$). The difference between the true signal and the realized terminal value is the random variable $\epsilon$, which captures all of the remaining uncertainty that cannot be resolved given the true intermediate state of the firm.

Although the certified third-party monitor provides the report $\theta$, we assume that the manager can influence the characteristics of this report. In particular, the manager chooses whether or not to manipulate information in order to bias the report made to the market. We assume that manipulation can be the outcome either of a manager who is able to hide information from the auditors or of a manager and an auditor who collude in hiding information; see Khalil and Lawarree (1995) for papers on optimal auditing with collusive behavior. If the manager does not manipulate, the third-party monitor’s report $\theta$ equals $y^T$. If, however, the manager manipulates, the third-party monitor’s report is $\theta = \theta^T + \alpha$, where $\alpha > 0$ denotes the upward bias in the report. For expositional purposes we will refer to $\alpha$ as the amount or the extent of the manipulation or bias. The stock price during this intermediate period, denoted $S$, is based on the market’s expectation of the terminal value given the third-party monitor’s report. Price formation is discussed further in Section 2.3 below.

We assume that in order to manipulate the monitor’s $t = 1$ signal the manager must divert some of the firm’s resources away from productive uses at $t = 0$. Because resources are diverted from more productive uses, manipulation carries an opportunity cost that lowers the terminal value of the firm. For simplicity, we assume that the resource cost of the manipulation is linear in the extent of the bias. That is, for an amount of bias $\alpha$, the gross terminal value realized at $t = 2$ falls by $\xi \alpha$, where $\xi > 0$ is the incremental resource cost. The resource cost will include such costs as the opportunity cost of the time managers spend maintaining a ruse, the cost of bribing an external auditor, or the cost of making inefficient decisions based on inaccurate information.

2.2. The compensation contract and the manager’s objective function

If contracts could be written solely on the realized terminal value of the firm (which is, by assumption, not subject to manipulation), then no manipulation would occur. In most realistic situations, however, the long run ($t = 2$) will be far enough in the future that such contracts will be impractical. Thus, we assume that the manager’s compensation is based on the market’s intermediate-run beliefs about the firm’s value as indicated by the stock price $S$ at $t = 1$. Note that the effect of manipulation we derive under this assumption is likely to be smaller in magnitude when the manager’s compensation has both a short-term and a long-term component. However, the qualitative nature of our results remains. We further assume that the manager’s wealth at $t = 1$, denoted $W$, derives solely from this compensation and that the contract is linear in $S$ : $W = \omega_0 + \omega_1 S$, where $\omega_0$ and $\omega_1$ are the parameters of the contract set by the entrepreneur at $t = 0$. The assumption of linear contracts is for tractability. Without loss of generality, we also assume that the manager’s reservation utility is zero.

In addition to the incentive contract, we assume that there exists a monitoring technology that can detect manipulation ex post with some probability. Here we differ from the signal-jamming literature which typically assumes that the quality of the agent’s action, such as project choice as in Narayanan (1985), is never (even randomly) observable or
contractible. Specifically, we let $r(0 < r < 1)$ denote the probability that the manager is caught manipulating, hereafter referred to as the detection probability. If caught, the manager is fined an amount $F$. For simplicity, we assume that $F = \phi z$, with $\phi(>0)$ defined as the incremental penalty. Thus, the incremental expected cost to the manager from manipulating an extra unit is $\phi r F$. One alternative to this formulation is to assume that the detection probability is increasing in the extent of the manipulation but the penalty is not. Under this alternative, none of the results change but the model solution becomes a bit more cumbersome and so we choose the former formulation.

Note that the monitoring technology can be interpreted as being due either to an internal governance mechanism or an external governmental agency responsible for enforcing disclosure laws, or a combination of the two. While the external regulatory agency is only interested in detecting those forms of manipulation that have been deemed to be illegal, the internal governance system might wish to limit or expand that set to include other manipulation activities that are costly to the firm. In addition, the extent of the penalty applied by the internal mechanism is likely to be limited to the firing of the manager, whereas the external regulatory agency can add the penalty of incarceration. In an attempt to keep the model as simple as possible, we do not distinguish between the legal and illegal types of manipulation. Rather, we let the manager pick the extent of the bias and assume that there is a single incremental cost to increasing this bias. Thus, we interpret the detection probability and penalty as being the result of the “aggregate” monitoring source.

Given the compensation contract and the regulatory environment, the manager’s $t = 0$ objective function in choosing effort and the extent of manipulation is

$$
E[U^M(\bar{W}, e, x) | O^M_0] = E[\bar{W} | O^M_0] - \frac{\gamma}{2} Var[\bar{W} | O^M_0] - \frac{\delta}{2} e^2 - \rho F - \gamma \rho (1 - \rho) F^2.
$$

where $O^M_0$ denotes the manager’s information set at $t = 0$. The first two terms represent the expected utility from risky compensation at $t = 1$, where $\gamma$ is the coefficient of absolute risk aversion. The manager’s compensation at $t = 1$ is a random variable with respect to the manager’s $t = 0$ information set because the manager does not know the realized value of $\eta$. The third term is the disutility of exerting effort $e$, with $\delta$ specifying the rate at which the marginal disutility increases with $e$. The last two terms represent the disutility from information manipulation. The first of these terms is the expected penalty while the last term is the disutility due to the uncertainty of being caught and penalized.

2.3. The market price at $t = 1$

We now discuss how manipulation affects the intermediate stock price. Here, we assume that all investors are rational and know all of the parameters in the model and can perfectly predict the equilibrium amount of manipulation. However, investors cannot observe either effort $e$ or the extent of manipulation $x$ and hence form the following conditional moments given the report of the third-party monitor:

$$
E[V - \xi x | \theta] = \theta - x^e - \xi x^e = \beta e + \eta + (x - x^e) - \xi x^e,
$$

(2)
and
\[ \text{Var}[V - \xi x | \theta] = \text{Var}[V | \theta] = \sigma_x^2, \]  
(3)
where \( x \) is the investors’ belief about the equilibrium amount of manipulation. When this belief is rational (so that in equilibrium \( x = x^* \) and \( x^* = x^* \), where \( x^* \) denotes the equilibrium level of manipulation) information manipulation has no impact on the rational expectation of the gross cash flow of the firm \( V \) (i.e., \( x - x^* = 0 \) in equilibrium. However, because the actual amount of manipulation is not observable and the amount of manipulation expected by investors in the intermediate period is fixed at \( x^* \), the investors’ expectation of the gross terminal value is increasing in the actual amount of manipulation \( x \) (see Stein, 1989, for a similar argument). The expected terminal value is decreasing in the expected extent of manipulation because investors subtract the expected extent of manipulation from the third-party monitor’s report and because they also reduce their expectation of the net terminal value by the cost of the diverted resources used in hiding this manipulation.

Once investors form expectations about future cash flows, all risk-averse investors choose the amount of the risky asset that maximizes their expected utility. We assume that investors have a negative exponential utility function of terminal wealth. As a result, the optimal demand at \( t = 1 \) for a typical investor \( i \) is given by

\[
X^i = \frac{E[V - \xi x - (\omega_0 + \omega_1 S)] - S}{\gamma \text{Var}^i(V)} = \frac{E[V - \xi x - (\omega_0 + \omega_1 S)] - S}{\gamma \text{Var}^i(V)}. 
\]  
(4)

The equilibrium stock price \( S \) solves the market-clearing condition \( \sum_{i=1}^N X^i = N \bar{X} \), where \( N \) denotes the number of investors and \( \bar{X} \) denotes the per-capita supply of the risky asset. Using investors’ distributions specified in Eqs. (2) and (3) above, the market-clearing condition implies

\[
S = \frac{1}{1 + \omega_1} \left[ (\beta e + \eta + (x - x^*) - x^* \xi - \omega_0) - \gamma \bar{X} \sigma_x^2 \right]. 
\]  
(5)

The term in the braces represents the expected gross terminal cash flow minus the fixed wage and the expected cost of diverted resources. The last term in the brackets is the risk discount applied to the mean cash flow to induce the risk-averse investors to hold the supply of the risky asset. The terms in the brackets are multiplied by \( 1/(1 + \omega_1) \) to reflect the \( \omega_1 S \) incentive compensation paid to the manager in period \( t = 1 \). Thus, the equilibrium price is the investors’ expected terminal cash flow net of compensation and the diverted-resource cost minus a risk premium.

3. Optimal compensation contract, effort, and manipulation

We solve for the subgame perfect equilibrium of the model by backward induction. First we solve for the optimal level of effort and manipulation chosen by the agent as a function of the parameters of the contract \( (\omega = (\omega_0, \omega_1)) \) offered by the entrepreneur: \( e(\omega) \) and \( x(\omega) \). Then, given the effect of the contract parameters on effort and manipulation, we determine the contract \( (\omega^* = (\omega_0^*, \omega_1^*)) \) that maximizes the entrepreneur’s expected wealth (or, equivalently, the firm’s initial stock price). This contract is the equilibrium contract and the
equilibrium levels of effort and manipulation are determined by the optimal effort and manipulation functions evaluated at this contract: \( e^* = e(\omega^*) \) and \( z^* = z(\omega^*) \). Lemma 1 specifies the optimal effort and manipulation as a function of the contract.

**Lemma 1.** The manager optimally responds to the contract \( \omega = (\omega_0, \omega_1) \) by exerting effort and manipulating as follows:

\[
e(\omega) = \frac{\hat{\omega}}{\delta} \beta, \tag{6}
\]

and

\[
z(\omega) = \max \left\{ 0, \frac{\hat{\omega} - \rho \varphi}{K} \right\}, \tag{7}
\]

where

\[
\hat{\omega} = \frac{\omega_1}{1 + \omega_1} \tag{8}
\]

is the pay-for-performance sensitivity of the manager’s compensation to (perceived) effort. The variable

\[
K \equiv 2 \gamma \rho (1 - \rho) \varphi^2 \tag{9}
\]

is the incremental impact of manipulation on the manager’s risk.

**Proof.** See the appendix.

As is usual, in order to induce the manager to exert effort, the principal must offer a contract that is sensitive to the stock price (i.e., \( \omega_1 > 0 \) and \( \hat{\omega} > 0 \)). In addition to inducing effort, however, \( \hat{\omega} > 0 \) also leads to manipulation if the manager’s incremental expected penalty \( \rho \varphi \) is sufficiently small relative to the manager’s incremental expected benefit \( \hat{\omega} \).\(^8\)

Thus, stock-based compensation induces both effort as in Eq. (6) and manipulation as in Eq. (7). From Eq. (7) one can see that the magnitude of information manipulation varies cross-sectionally with several firm and managerial characteristics as well as with policy parameters. For example, \( \hat{\omega} \) (and hence \( z \)) is determined in equilibrium by such things as firm-specific risk, managerial productivity, and the manager’s cost of effort.

Next we consider the contract chosen by the entrepreneur who maximizes the expected net terminal value of the firm taking into consideration how the contract affects the amount of effort and manipulation chosen by the manager. Specifically, the entrepreneur solves the following problem:

\[
\text{Max}_{\omega_1, \omega_0} E[V_2], \tag{10}
\]

\(^8\)Eq. (7) raises the question of why regulators do not set the marginal penalty, \( \varphi \), so that manipulation is zero. While casual observation of the existence of manipulation (and outright fraud) suggests that regulators do not do so, theoretically there are several possible reasons why it might not be optimal to have a large penalty. For example, Andreoni (1991) argues that in a judicial system that is based on the concept of “reasonable doubt,” increasing the penalty will result in a lower conviction rate because jurors will be less willing to convict. Stigler (1970) argues that increasing the marginal penalty on one crime will induce criminals to shift towards other crimes. Thus, while our paper is not about the optimal choice of a legal system, the above is suggestive of why fraud can still exist in equilibrium.
subject to:

$$E[U^M(W) | \Omega_0^M] \geq 0,$$  

and

$$\{e(\bullet), z(\bullet)\} = \arg\max E[U^M(W) | \Omega_0^M].$$

Constraints (11) and (12) are, respectively, the participation and incentive compatibility constraints. Note that it can be easily shown that the above problem is equivalent to that solved by a principal with a short horizon who seeks to maximize the expectation of the intermediate stock price. As will be discussed in Section 5, only if there are investors who underestimate the equilibrium extent of manipulation will there be a difference between the contracts chosen by short- and long-horizon entrepreneurs.

The following lemma specifies the equilibrium contract chosen by the entrepreneur.

Lemma 2. Define

$$\Psi = \frac{(\beta / \delta) - (\xi / K)}{(\beta^2 / \delta) + \gamma \sigma_n^2 + (1 / K)}.$$  

If $$\rho \phi < \Psi$$, the equilibrium amount of manipulation is positive ($$x^* > 0$$) and the equilibrium pay-for-performance sensitivity $$\hat{\omega}^* = \omega_1^*/(1 + \omega_1^*)$$ is

$$\hat{\omega}^* = \Psi. \quad (13)$$

If $$\rho \phi \geq \Psi$$, then $$x^* = 0$$ and

$$\hat{\omega}^* = \frac{\beta / \delta}{(\beta^2 / \delta) + \gamma \sigma_n^2}. \quad (14)$$

The fixed component of the equilibrium contract, $$\omega_0^*$$, is that which makes the participation constraint given by Eq. (11) bind.

Proof. See the appendix.

If the incremental expected penalty is sufficiently large (i.e., $$\rho \phi \geq \Psi$$), then the compensation contract need not balance the benefit of effort against the cost of manipulation. In that case, the equilibrium pay-for-performance sensitivity is as in the standard agency model when manipulation is not possible: $$\hat{\omega}_{\text{NoManip}}^* = \frac{\beta / \delta}{(\beta^2 / \delta) + \gamma \sigma_n^2}$$. If, however, the manager’s incremental expected penalty $$\rho \phi$$ is insufficient to prevent manipulation (i.e., $$\rho \phi < \Psi$$), the equilibrium pay-for-performance sensitivity is a function of the incremental resource cost $$\xi$$, the detection probability and the incremental penalty imbedded in $$K$$. Comparing Eqs. (13) and (14) we see that the equilibrium pay-for-performance sensitivity is smaller when the level of manipulation is positive than when the level of manipulation is zero. This is true because manipulation introduces two extra costs. The first cost is the resource cost, captured by the term $$-\xi / K$$. The second cost is the additional risk borne by the manager, captured by the term $$+1 / K$$ in the denominator. For the remainder of the paper, we will consider only situations in which the regulatory environment is such that $$x^* > 0$$. That is, we assume that $$\rho \phi < \Psi$$. 

4. Cross-sectional and policy implications

The goal of this section is to develop a set of cross-sectional implications that predict how pay-for-performance sensitivity and extent of manipulation vary with observable firm (or industry) characteristics that proxy for the model’s parameters. To do this, we first derive comparative-static results with respect to the usual set of parameters analyzed in previous theoretical studies, including risk aversion \( (\gamma) \), disutility of effort \( (\delta) \), managerial productivity \( (\beta) \), and intrinsic uncertainty \( (\sigma^2) \). We then provide comparative-static results with respect to changes in the parameters that characterize the manipulation environment, including the detection probability \( (\rho) \), the incremental penalty \( (\varphi) \), and the incremental resource cost \( (\zeta) \). Finally, we relate the cross-sectional results to existing empirical studies that examine cross-sectional variation in pay-for-performance sensitivity and we discuss the impact of regulatory reform.

4.1. Comparative-static results

The following proposition, implied by Lemmas 1 and 2, specifies a set of comparative-static results that characterize the equilibrium relation between pay-for-performance sensitivity and the extent of manipulation with respect to the standard parameters that characterize agency problems.

**Proposition 1.**

(i) \( d\hat{\omega}^*/d\sigma^2 < 0 \) and \( dx^*/d\sigma^2 < 0 \).

(ii) \( d\hat{\omega}^*/d\delta < 0 \) and \( dx^*/d\delta < 0 \).

(iii) Both \( d\hat{\omega}^*/d\gamma \) and \( dx^*/d\gamma \) can be either positive or negative.

(iv) There exists a constant \( \beta^C \) such that \( d\hat{\omega}^*/d\beta > 0 \) and \( dx^*/d\beta > 0 \) if and only if \( \beta^C > \beta \).

**Proof.** See the appendix.

The intuition for parts (i) and (ii) is straightforward. As the uncertainty in the stock price increases or as the cost of effort goes up, a given pay-for-performance sensitivity generates more risk or a higher disutility of effort for the manager. Thus, the cost of inducing the manager to exert a high effort goes up and the entrepreneur responds by lowering the pay-for-performance sensitivity so as to induce less effort. This is the same effect that occurs even if there is no possibility of manipulation. Note, however, that as these parameters increase, the extent of manipulation falls but only as a result of the drop in pay-for-performance sensitivity. That is, by Eq. (7) in Lemma 1, these parameters have no direct effect on the extent of manipulation.

Part (iii) is less intuitive and is counter to the standard result in which an increase in risk aversion leads to a decrease in stock-based compensation. Here, stock-based compensation can either increase or decrease. This result occurs because as risk aversion increases, in addition to effort becoming more expensive to induce (given the risk in the measurement of performance), manipulation also becomes more expensive because the disutility of the risk associated with the penalty from being caught increases. While the first effect reduces pay-for-performance sensitivity, the second effect increases it. As a result, the principal could choose to increase incentive compensation, for example, whenever uncertainty is low or whenever the benefit of effort is high. The same is true with respect to manipulation. Here,
a more risk-averse manager will be less inclined to manipulate on the one hand but could also receive a contract with higher stock price sensitivity on the other (as explained above). Thus, for example, a more risk-averse manager will engage in more manipulation when productivity of effort is high.

Finally, the intuition for part (iv) is that higher levels of productivity increase both the benefit of effort and the equilibrium cost of inducing effort. Because the cost function is convex, there is a point from which the cost outweighs the benefit. Thus, the pay-for-performance sensitivity will increase with productivity only for low levels of productivity. The same will be true for the level of manipulation because manipulation and pay-for-performance sensitivity are positively related. The effect of managerial productivity ($\beta$) on manipulation, similar to $\sigma^2$ and $\delta$, is only via its indirect effect on the pay-for-performance sensitivity.

Proposition 2 below provides a set of comparative-static results that characterize how the parameters that describe the monitoring and manipulation environment affect pay-for-performance sensitivity. For expositional reasons, we postpone the analysis of the cross-sectional implications regarding the extent of manipulation to Propositions 3 and 4.

**Proposition 2.** The following comparative-static results hold for the equilibrium pay-for-performance sensitivity $\hat{\omega}^*$:

(i) $d\hat{\omega}^*/d\rho > 0$.
(ii) Assuming $\rho < .5$, $d\hat{\omega}^*/d\rho > 0$.
(iii) $d\hat{\omega}^*/d\xi < 0$.

**Proof.** See the appendix.

The intuition for the above results is as follows. Stock-based compensation is a double-edged sword in that it induces the manager to exert effort (which increases terminal value) and to engage in misrepresentation (which reduces the terminal value via the misallocation of resources). The equilibrium pay-for-performance sensitivity $\hat{\omega}^*$ is set by the entrepreneur to balance the incremental value of effort against the incremental cost of manipulation. Because both an increase in the detection probability and/or the penalty of manipulation reduce the manager’s incentive to engage in such activity, the entrepreneur responds to increases in these parameters by increasing the pay-for-performance sensitivity. On the other hand, an increase in the resource cost $\xi$ increases the direct cost of manipulation to the entrepreneur, which implies that the entrepreneur will want to reduce manipulation by lowering the pay-for-performance sensitivity.

Note that as the incremental resource cost goes to zero one would expect that the incentive to monitor will also fall. In that case the expected penalty (detection probability and incremental penalty) will also fall toward zero, and the equilibrium extent of manipulation will increase toward infinity. This situation is not very realistic, however, as it relies on the cost of hiding an increasingly outrageous fabrication going to zero.

### 4.2. Empirical implications on pay-for-performance

Several recent empirical studies, discussed below, examine how the characteristics of incentive contracts vary cross-sectionally with various firm characteristics. For the most part, these studies do not consider how the potential for manipulation affects equilibrium
contracts. In this section we reinterpret some of these empirical results taking into account the effects of manipulation and monitoring on the equilibrium contract. The underlying motivation of this analysis is similar to that in Aggarwal and Samwick (1999), which shows that estimates of pay-for-performance sensitivity that do not condition on the variance of the stock return are biased downward due to the standard omitted-variable bias. In this spirit, we argue that existing studies that do not condition on variables that characterize the manipulation and monitoring environment can also suffer from an omitted-variable bias. We also argue that, aside from any omitted-variable bias, our model provides an alternative to the interpretations of low pay-for-performance sensitivities found in the literature. For example, Bebchuk and Fried (2003), as well as the studies discussed below, argue that low pay-for-performance sensitivities are indicative of captured and weak boards. In contrast, our analysis shows that low pay-for-performance sensitivities can be consistent with a well-functioning board rationally responding to particular manipulation/monitoring conditions.

The results of Proposition 2 are consistent with several empirical observations documented in recent work by Murphy (1999), Hartzell and Starks (2003), and Fahlenbrach (2003). For example, Murphy (1999) shows that pay-for-performance sensitivity is negatively related to the size of the firm. Because size is likely to be positively correlated with the ability to hide information manipulation, this result is consistent with our prediction that a lower detection probability leads to a lower pay-for-performance sensitivity. While Murphy suggests that this could be a result of managerial wealth constraints and risk aversion, our model identifies an independent effect that should hold once these variables are controlled for.

Hartzell and Starks (2003) find that pay-for-performance sensitivity is higher for firms with more institutional ownership after controlling for firm size and Tobin’s q. This is also consistent with our model. Because higher institutional ownership implies greater monitoring, the likelihood of detection is higher and, as a result, the board optimally responds by increasing pay-for-performance sensitivity. In a similar vein, Fahlenbrach (2003) shows that firms with weaker governance are run by CEOs who hold a smaller fractional ownership stake in the firm. If weaker governance implies a lower expected penalty for manipulation, then, by Proposition 2, the board will decrease pay-for-performance sensitivity so as to reduce the manager’s incentive to manipulate information.

As mentioned above, our model offers a different interpretation of the empirical studies above and of the argument promoted by Bebchuk and Fried (2003) that low pay-for-performance is indicative of captured boards. Hartzell and Starks (2003) and Fahlenbrach (2003) argue that their empirical findings are evidence that managers have undue control over their own compensation under weaker governance systems. According to their argument, weak governance or low monitoring is associated with compensation that is not very sensitive to performance because managers who face weak boards can exploit shareholders and obtain compensation that is not sensitive to poor performance. The results of our model, however, show that the combination of low pay-for-performance and weak governance need not be due to managers having undue influence over the board. Rather, in our model, this combination will hold under the optimal contract chosen by an independent board that maximizes shareholder value. Thus, without further investigation, it cannot be concluded that low pay-for-performance is symptomatic of boards that do not effectively represent shareholders interests.
Finally, because the incremental resource cost and the detection probability might not be independent of each other but could both vary with the complexity of the firm’s operations and the strength of the firm’s internal governance, the relation between the pay-for-performance sensitivity and operational complexity or governance could be ambiguous. However, as long as the impact of the firm’s internal governance is stronger for the detection probability than it is for the resource cost, the net effect will be that worse governance leads to lower pay-for-performance sensitivity.

The relative importance of the two above effects is an empirical question. Theoretically, however, there clearly are firm or managerial characteristics that affect the resource cost independently of the detection probability. For example, cross-sectional variation in the opportunity cost of the manager’s time will imply cross-sectional variation in resource costs but not detection probabilities. The resource cost is likely to depend strongly on the level of competition and growth in the firm’s industry. In highly competitive and high-growth industries, a manager who is preoccupied with falsifying information could lose out on potential new and lucrative growth opportunities for the firm.

In conclusion, while our model has implications on how internal monitoring and governance can affect pay-for-performance sensitivity, it is clear that, when applying our model to data, it is important to obtain information that can characterize which factors have the biggest effect on the exogenous variables.

4.3. Manipulation and policy implications

The second main contribution of our paper is an analysis of the impact of regulatory reform on the manager’s incentive to manipulate information. For this analysis, we interpret the relevant detection probability, incremental penalty, and incremental resource cost as policy parameters determined by the external regulatory environment concerned with fraudulent behavior.

Below we analyze how the policy parameters affect the equilibrium level of information manipulation given both their direct effect on manipulation and their indirect effect on manipulation via their impact on the equilibrium pay-for-performance sensitivity (as in Proposition 2). The next proposition shows that an increase in the detection probability and/or the incremental penalty that is intended to decrease the extent of manipulation can actually increase manipulation.

**Proposition 3.** There exists a non-empty set of parameters under which the equilibrium amount of manipulation $\gamma^*$ is increasing in the incremental penalty $\varphi$ or the detection probability $\rho$. A sufficient condition for $d\gamma^*/d\varphi > 0$ is that the elasticity of $\gamma^*$ with respect to $\varphi$ is greater than 2, and a sufficient condition for $d\gamma^*/d\varphi < 0$ is that the elasticity of $\gamma^*$ with respect to $\varphi$ is less than 1. Alternatively, there exists a constant $\zeta_{\text{crit}}$ such that $d\gamma^*/d\varphi > 0$ for all $\zeta > \zeta_{\text{crit}}$.

**Proof.** See the appendix.

The intuition for these results is as follows. The equilibrium pay-for-performance sensitivity is set so as to balance the net benefit from inducing effort and the cost of inducing manipulation. Consider, for example, the effect of an increase in the incremental penalty, $\varphi$. As $\varphi$ increases, holding fixed the pay-for-performance sensitivity, the manager’s incentive to manipulate decreases. Hence, because information manipulation
is costly, the entrepreneur will respond to the manager’s decreased incentive to manipulate by increasing the pay-for-performance sensitivity. This is because in increasing the pay-for-performance sensitivity the entrepreneur also increases the manager’s incentive to exert effort. Thus, depending on the elasticity of the pay-for-performance sensitivity to $\varphi$, the increase in manipulation due to the indirect effect from the increase in the pay-for-performance sensitivity could be large enough to completely overturn the decrease in manipulation due to the direct effect created by the increase in $\varphi$, resulting in a net increase in information manipulation. This situation occurs, for example, when the resource cost $\xi$ is high, in which case the pay-for-performance sensitivity and effort are low and hence the net marginal benefit of effort alone is high. Similarly, this occurs whenever uncertainty is high (i.e., $\sigma_{\eta} > \sigma_{\eta}^{\text{crit}}$) and when productivity is low (i.e., $\beta < \beta^{\text{crit}}$). In these cases the goal of public policy to reduce information manipulation or fraud by increasing penalties will be ineffective.

Interestingly, an increase in the penalty always improves welfare regardless of whether the level of information manipulation decreases or increases. This is true because the level of effort is lower than it would be without the possibility of manipulation. An increase in the penalty (which can be achieved costlessly) increases the pay-for-performance sensitivity, which, in turn, raises the equilibrium level of effort. Consider the following argument. If, after the penalty is increased, the entrepreneur does not change the pay-for-performance sensitivity, then the level of effort will remain at its original level and the amount of manipulation will fall, reducing the amount of resources lost. The entrepreneur might have to change the fixed component of the wage in order for the manager to participate. Once this occurs, the expected utility of the manager is as it was before the penalty increase—at her reservation utility. In addition, investors’ expected utilities also remain unchanged because, by the market-clearing condition and investor homogeneity, their expected utility is solely a function of the amount of risk in the market, which is independent of the amount of both effort and manipulation in this model. Because the level of effort remains unchanged, the expected terminal value of the firm must increase due to fewer resources being diverted for information manipulation. The entrepreneur, however, will respond to the increased penalty by changing the pay-for-performance sensitivity, but only if it increases the expected value of the firm, which, by assumption, the entrepreneur maximizes. Thus, any change, whether it results in more or less information manipulation, increases welfare. This result implies that welfare and the level of manipulation need not be inversely related.

One of the features of the recent regulatory reform of the accounting industry is to separate the provision of certified accounting services from the provision of consulting services. It was believed that firms that employed an accounting firm to provide both types of services could use the lucrative consulting contract as leverage to induce the accounting firm to misrepresent its accounting statements in favor of the firm. Separating of the provision of these services would prevent this leverage and thus would discourage the extreme form of manipulation that is fraud. In the context of our model, this separation essentially increases the cost of committing fraud by forcing managers to adopt more surreptitious routes to hide their fraudulent activity. By eliminating a fairly efficient avenue through which managers can induce third-party monitors to misrepresent value, the new regulations essentially require that managers use less efficient (i.e., higher $\xi$) avenues to induce misrepresentation. Thus, the separation policy increases the incremental resource
cost $\xi$. In the context of fraud, the following two propositions specify the impact of such a policy.

**Proposition 4.** The equilibrium amount of fraud $x^*$ is decreasing in $\xi$ for all parameters.

While an increase in the incremental resource cost $\xi$ unambiguously reduces the extent of fraud (because it reduces $\omega^*$), it also affects the expected value of the firm in two ways. First, as the incremental resource cost increases for a fixed amount of fraud, the terminal value falls to reflect the increased cost of fraud. Second, the entrepreneur responds by changing the contract so that the equilibrium amount of fraud falls. The drop in fraud, for a fixed resource cost, implies an increase in the expected value of the firm. If the drop in the fraud is fairly small, then the direct effect of the increased resource cost will dominate and reduce the mean terminal net value. If the drop in fraud is large, however, then the expected net terminal value can rise. The following proposition specifies which occurs in equilibrium.

**Proposition 5.** An increase in $\xi$ results in a reduction of the firm’s expected net terminal value $V - x^*\xi - (\omega_0^* + \omega_1^*S)$ and the intermediate price $S$.

**Proof.** See the appendix.

A change in $\xi$ affects the net cash flow both directly and indirectly through its impact on the optimal contract. Due to the envelope theorem, because the contract is chosen optimally to maximize net cash flows, at the optimum the change in the contract due to a change in $\xi$ will have a zero net effect. Thus, an increase in $\xi$ will result in a lower net terminal value.

5. The equilibrium when some investors underestimate the bias

We now consider a variation of the basic model in which some investors are fooled by manipulated reports. In this case, manipulation can positively affect the intermediate stock price while negatively affecting the long-term stock value. The main goal of this section is to discuss how the composition of the pool of investors affects the equilibrium. We argue that the horizon of the controlling shareholders (or the entrepreneur) that set the compensation contract is critically important.

To analyze the above issue, we consider a model with two types of investors: a set of investors that can perfectly predict the equilibrium level of manipulation and a set of “naïve” investors who underestimate this equilibrium level. There are two possible ways to interpret the expectations of naïve investors. One interpretation is that these investors do not have rational expectations and systematically underestimate the extent of manipulation in the economy. An alternative interpretation is that these investors do not possess enough information about the relevant parameters or about the equilibrium relation between these parameters and manipulation. If these investors have rational expectations based upon incomplete information, then they would be equally likely to underestimate as overestimate the extent of manipulation. Below we analyze only the equilibrium that obtains when the naïve investors’ incomplete information results in an underestimate of manipulation, which seems to be the more relevant description of recent episodes in the
market. News reports have documented many instances of investors saying that they were surprised at the existence and extent of manipulation.\footnote{It is possible that in the period following the corporate scandals in early 2000 there was a set of naive investors who overestimated the equilibrium extent of manipulation, potentially resulting in overly depressed prices. We do not analyze this situation explicitly as the results are fairly obvious given the analysis we do present.}

To impose some structure on the problem we assume that a fraction \( m (0 \leq m \leq 1) \) of investors are naïve and expect that \( a^e = \lambda a^* \) (where \( 0 \leq \lambda \leq 1 \)) while a fraction \( 1 - m \) of investors have enough information to perfectly predict the equilibrium level of manipulation \((a^e = a^*)\). When either \( m = 0 \) or \( \lambda = 1 \), all investors perfectly predict the level of manipulation. At the other extreme, when \( m = 1 \) and \( \lambda = 0 \), all investors naively believe that there is no manipulation. For \( \lambda \) between zero and one, the naïve investors believe that there is some manipulation but that it is not as large as it actually is.

In this setting, the intermediate stock price becomes

\[
S = \frac{1}{1 + \omega_1} [\beta e + \eta + x - (1 + \zeta)(1 - m + \lambda m) a^e - \omega_0 - \gamma \bar{X} \sigma^2].
\]  

(15)

Given a compensation contract based on this intermediate stock price, it can be easily shown that when the entrepreneur seeks to maximize the expected net terminal value of the firm, the equilibrium levels of effort, manipulation, and pay-for-performance sensitivity are the same as when \( m = 0 \). This is because the long-horizon entrepreneur is not affected by the stock price and hence maintains the same pay-for-performance sensitivity as before. Thus, the existence of naïve investors has no material effect on the equilibrium.

In contrast, when we have a short-horizon entrepreneur who seeks to maximize the expected intermediate stock price, the entrepreneur can benefit from both effort and manipulation. In this case it can be shown that the pay-for-performance sensitivity set by a short-horizon entrepreneur is

\[
\hat{o}^{**S} = \frac{\beta/\delta + (Z/K)}{\gamma \sigma^2 + (\beta^2/\delta) + (1/K)},
\]  

(16)

where \( Z = m(1 - \lambda)(1 + \zeta) - \zeta \).

When all investors perfectly predict the extent of manipulation, there is no difference between the equilibrium under a short-horizon entrepreneur and a long-horizon entrepreneur. However, when a nonzero fraction of investors are naïve about the expected level of manipulation, then manipulation can have an additional positive impact on the intermediate stock price. This in turn affects the contract written by the short-horizon entrepreneur. The following corollary provides a set of comparative-static results on how the composition of the investor population affects the equilibrium.

**Corollary 1.** The stock price \( S \), the level of manipulation \( a^* \), and the pay-for-performance sensitivity \( \hat{o}^{**S} \) are all increasing in the percent of investors that are naïve, \( m \).

**Proof.** See the appendix.

As the percentage of naïve investors increases, there is an increase in both the equilibrium amount of manipulation and stock-based compensation. In addition, concurrent with the increase in manipulation is an increase in the intermediate stock price \( S \). Eventually, however, the stock price will experience declines as the manipulated
upward-biased claims fail to materialize and as the net terminal value reflects the loss of valuable resources diverted to hide the manipulation. These comparative-static results roughly correspond to the boom and bust cycle experienced in the late 1990s, when there was increased market participation by investors who could be considered less sophisticated and likely to underestimate the extent of manipulation and fraud.

In addition to the results in Corollary 1, it can also be shown that the average intermediate stock price under the short-horizon contract is higher than the average price under the long-horizon contract. The intuition for this result is as follows. The short-horizon board chooses the contract to maximize the intermediate stock price while the long-horizon board chooses the contract to maximize the expected final cash flow. Thus, by definition of $\omega^S$, $ES(\omega^S) \geq ES(\hat{\omega}^S)$.

This implies that the board faces a tradeoff between offering a long-term contract, which reduces inefficient manipulation but has a lower intermediate stock price (and thus a higher probability of shareholders wanting to replace the board), and offering a short-term contract, which increases inefficiency but also results in a higher intermediate stock price (and hence increases the probability of the board being retained). If there is strong shareholder activism and the shareholders evaluate the performance of the current board by comparing their stock price with similar firms in their industry, then the long-horizon board will appear to be performing worse than a short-horizon board. As a result, the long-horizon board risks being unseated. If the horizon of the board is endogenously determined, then self-interested boards will have short horizons and, as a consequence, there will be more manipulation and lower ultimate value. In a different setting Bolton et al. (2005) argue that when some investors are overconfident, optimal contracts can have a short-term component that induces the manager to pursue (inefficient) short-term actions.

6. Conclusion

In this paper we find that stock-based compensation acts as a double-edged sword, inducing beneficial effort on the one hand and costly information manipulation activity on the other. In equilibrium, the pay-for-performance sensitivity of the contract is set so as to strike a balance between effort and manipulation.

Given this balance, we show that the equilibrium pay-for-performance sensitivity will vary cross-sectionally with variables that characterize manipulation and monitoring in a manner that is consistent with recent empirical results. For example, we show that firms facing a lower detection probability (e.g., larger firms with more complex business operations) will have lower pay-for-performance sensitivity, consistent with Murphy (1999) who documents that pay-for-performance sensitivities are typically lower in larger firms. More generally, we show that weaker governance should lead to lower pay-for-performance sensitivity, consistent with evidence in Hartzell and Starks (2003) and Fahlenbrach (2003) who show that pay-for-performance sensitivity increases with various measures of the influence of minority shareholders and with the strength of the firm’s corporate governance system. Thus, our model challenges the view in Bebchuk and Fried (2003) that observing weak governance and low pay-for-performance is a result of a captured board.

In addition, we find that public policy actions designed to reduce the amount of misrepresentation (for example, increases in penalties and detection probabilities for
manipulation) may sometimes increase manipulation behavior. This is because the benefit of manipulation (i.e., the pay-for-performance) is endogenously chosen in response to the regulatory system. Furthermore, we show that while the separation of accounting and consulting services will unambiguously reduce the amount of misreporting, it will also unambiguously reduce firm value. Finally, the paper examines the case in which some investors are not fully informed about the true extent of manipulation. In this case we show that a short-horizon principal will offer a contract that induces greater amounts of manipulation than that induced by a long-horizon principal and that this can potentially result in principals endogenously choosing to have a short horizon. We further show that when a larger fraction of the market is naı¨ve about the full extent of manipulation, there will be more stock-based compensation, higher levels of manipulation, and higher stock prices, leading to an eventual fall in prices once these potentially fraudulent reports begin to clash with true revelations of cash flows.

Appendix

Proof of Lemma 1. Given the stock price function in Eq. (5), at $t = 0$ the manager understands that the stock price at $t = 1$ will be normally distributed with the following moments:

$$E[S|\Omega^M_0] = \frac{1}{1 + \omega_1}[\beta e + \alpha - \bar{x}(1 + \bar{\xi}) - \omega_0 - \gamma \bar{X} \sigma^2]$$  \hspace{1cm} (A.1)

and

$$Var[S|\Omega^M_0] = \left(\frac{1}{1 + \omega_1}\right)^2 \sigma^2_n,$$  \hspace{1cm} (A.2)

where $\Omega^M_0 = \{e, \alpha, \omega_0, \omega_1, \Psi\}$ and $\Psi$ denotes the set of parameters that characterize the economy (i.e., $\Psi = \{\mu, \gamma, \varphi, \rho, \xi, \beta, \sigma^2\}$). Thus, the expected utility of the manager is

$$E[U^M(W)|\Omega^M_0] = E[\omega_0 + \omega_1 S|\Omega^M_0] - \rho \varphi \alpha - \frac{\gamma}{2}[\hat{\sigma}^2 \sigma^2_n + 2\rho(1 - \rho)\varphi^2 \bar{x}^2] - \frac{\delta}{2} e^2.$$  \hspace{1cm} (A.3)

Substituting the expression for the intermediate price in Eq. (5) in the text for $S$ and taking expectations yields

$$E[U^M(W)|\Omega^M_0] = \omega_0 + \frac{\omega_1}{1 + \omega_1}[\beta e + \alpha - (1 + \bar{\xi}) \bar{x} - \omega_0 - \gamma \bar{X} \sigma^2_e] - \rho \varphi \alpha$$

$$- \frac{\gamma}{2}[\hat{\sigma}^2 \sigma^2_n + 2\rho(1 - \rho)\varphi^2 \bar{x}^2] - \frac{\delta}{2} e^2.$$  \hspace{1cm} (A.4)

The first-order conditions with respect to $\epsilon$ and $\alpha$ yield the result stated in the lemma. \hfill \Box

Proof of Lemma 2. The entrepreneur picks the contract to maximize the expected residual terminal value net of the wage payment in $t = 2$. The expected residual value is

$$E_0[V - \xi \alpha - (\omega_0 + \omega_1 S)|\omega_1, \omega_0^0] = \beta e^0 - \xi \bar{x}^0 - E_0[\omega_0 + \omega_1 S],$$  \hspace{1cm} (A.5)

where $E_0[\cdot]$ denotes the expectations operator conditional on information available to the entrepreneur at $t = 0$. Because $\omega_0$ will be set so as to make the participation constraint
Eq. (11) bind, Eq. (A.3) implies that for a given contract $\omega$ that makes the participation constraint bind,

$$E_0[\omega_0 + \omega_1 S] = \rho \varphi x(\omega) + \frac{\gamma}{2} [\omega^2 - \sigma^2 + 2\rho(1-\rho)\varphi^2 x(\omega)^2] + \frac{\delta}{2} e(\omega)^2,$$

where $e(\omega)$ and $x(\omega)$ are as in Lemma 1. Thus, the entrepreneur’s objective function simplifies to

$$E_0[V - \xi x - (\omega_0^* + \omega_1 S) | \omega_1, \omega_0^*]$$

$$= \beta e(\omega) - \xi x(\omega) \left( \rho \varphi x(\omega) + \frac{\gamma}{2} [\omega^2 - \sigma^2 + 2\rho(1-\rho)\varphi^2 x(\omega)^2] + \frac{\delta}{2} e(\omega)^2 \right).$$

Because according to Lemma 1 $e(\omega)$ and $x(\omega)$ are functions of $\omega$ (and not $\omega_0$), the entrepreneur’s objective function is simply a function of $\hat{\omega}$ and parameters. Substituting in the expressions for $e(\omega)$ and $x(\omega)$ and taking the first-order condition with respect to $\hat{\omega}$ yields the equilibrium pay-for-performance sensitivity $\hat{\omega}^*$ specified in the Lemma. The fixed component of the equilibrium contract $\omega_0^*$ is obtained by imposing the participation constraint given the equilibrium pay-for-performance sensitivity $\hat{\omega}^*$. □

**Proof of Proposition 1.** First note that the sign of the derivative of $\omega_0^*$ is the same as the sign of the derivative of $\hat{\omega}^*$. Parts i and ii of the proposition can be seen immediately after calculating the relevant derivatives. As for part iii, note that

$$\frac{d\hat{\omega}^*}{d\gamma} = \frac{\partial \hat{\omega}^*}{\partial K} \frac{dK}{d\gamma} + \frac{\partial \hat{\omega}^*}{\partial \gamma}.$$ 

Because the first term is positive and the second term is negative, the sign of the total derivative can be either positive or negative, depending on parameter values. Similarly,

$$\frac{dx^*}{d\gamma} = \frac{\partial x^*}{\partial \hat{\omega}^*} \frac{d\hat{\omega}^*}{d\gamma} + \frac{\partial x^*}{\partial K} \frac{dK}{d\gamma}.$$ 

Here, the first term can be either positive or negative (depending on the sign of $d\hat{\omega}^*/d\gamma$) while the second term is negative. Thus, again the aggregate sign of the total derivative can be positive or negative.

Finally, a somewhat tedious calculation can show that $\text{Sign}[d\hat{\omega}^*/d\beta] = \text{Sign}[-a\beta^2 + b\beta + c]$, where $a$, $b$, and $c$ are positive. The result follows. □

**Proof of Proposition 2.** To prove this proposition it will be useful to find the sign of the following partial derivative:

$$\frac{\partial \hat{\omega}^*}{\partial K} = \frac{\xi/K^2((\beta^2/\delta) + \gamma \sigma^2 + (1/K)) + 1/K^2((\beta/\delta) - (\xi/K))}{((\beta^2/\delta) + \gamma \sigma^2 + (1/K))^2}.$$ 

Because this derivative is positive the following is true:

i. $d\hat{\omega}^*/d\varphi = (\partial \hat{\omega}^*/\partial K)(dK/d\varphi) > 0$ because both derivatives are positive.

ii. $d\hat{\omega}^*/d\rho = (\partial \hat{\omega}^*/\partial K)(dK/d\rho) > 0$ again because $\partial \hat{\omega}^*/\partial K > 0$ and because $dK/d\rho = 2\gamma \varphi^2(1-2\rho)$ as long as $\rho < 0.5$.

iii. Finally, it is obvious that $d\hat{\omega}^*/d\xi < 0$. □
Proof of Proposition 3. Below we provide results for \( \frac{dx^*}{d\phi} \).

\[
\frac{dx^*}{d\phi} = \frac{1}{K} \left( \frac{\tilde{\omega}^*_q}{\tilde{\omega}^*_q - \rho} \right) - \frac{2(\tilde{\omega}^*_q - \rho \phi)2\gamma(1 - \rho)\phi}{K^2} \\
= \frac{\dot{\omega}^*_q}{K\phi} \left[ \frac{\tilde{\omega}^*_q / \tilde{\omega}^*_q - 2 + \rho \phi}{\tilde{\omega}^*_q} \right].
\]

Because \( 0 \leq \rho \phi / \dot{\omega}^*_q \leq 1 \), the result follows. Alternatively, one can continue to simplify (A.8) to obtain,

\[
\frac{dx^*}{d\phi} = a_0 + a_1 \zeta,
\]

where

\[
a_1 = \frac{2\beta^2 / \delta K + 2\gamma\sigma^2_n / K + 1 / K^2}{((\beta^2 / \delta) + 2\gamma\sigma^2_n + (1 / K)^2)} > 0.
\]

Hence, for \( \zeta \) sufficiently large (i.e., \( \zeta > \zeta_{\text{crit}} \)) \( (dx^*/d\phi) > 0 \). Note that (if for simplicity we let \( \beta = 1 \))

\[
\zeta_{\text{crit}} = \left[ \frac{2\delta(2K(1 + \delta^2\sigma^2_n + \delta))}{[K(1 + \delta^2\sigma^2_n + \delta)]^2} \right]^{-1} \left\{ \frac{2K^2(1 + \delta^2\sigma^2_n + \delta)}{[K(1 + \delta^2\sigma^2_n + \delta)]^2} - \rho \phi \right\} \Rightarrow \text{ (A.10)}
\]

\[
\zeta_{\text{crit}} = \frac{K}{\delta} \left[ \frac{K(1 + \delta^2\sigma^2_n)}{2K(1 + \delta^2\sigma^2_n + \delta)} \right] - \left[ \frac{2\delta(2K(1 + \delta^2\sigma^2_n + \delta))}{[K(1 + \delta^2\sigma^2_n + \delta)]^2} \right]^{-1} \rho \phi. \text{ (A.11)}
\]

Because the term in brackets in the first term is less than 1 and the second term in brackets is positive, \( \zeta_{\text{crit}} < K / \delta \). Because \( \dot{\omega}^*_q \) is positive whenever \( \zeta_{\text{crit}} < K / \delta \), then \( dx^*/d\phi > 0 \) and \( \dot{\omega}^*_q > 0 \) can hold simultaneously. \( \square \)

Proof of Proposition 5. Recall that in equilibrium \( V_2 = \beta e^* + \eta + e = x^* \zeta - (\omega^*_q + \omega^*_1 S) \). Thus, \( dE[V_2] / d\zeta = (\tilde{\omega}^*_q / \tilde{\omega}^*_q)(\tilde{\omega}^*_q / \tilde{\omega}^*_q) + (\tilde{\omega}^*_q / \tilde{\omega}^*_q) \). By the envelope condition, \( \tilde{\omega}^*_q / \tilde{\omega}^*_q = 0 \). Because \( \tilde{\omega}^*_q = -x^* \), \( dE[V_2] / d\zeta = -x^* \leq 0 \). \( \square \)

Proof of Corollary 1. From Eq. (16) it is straightforward to show that both \( \dot{\omega}^*_q \) and hence \( x^* \) are increasing in \( \mu \). As for the stock price \( S \), note that \( dS / d\mu = (\dot{\omega}^*_q / \dot{\omega}^*_q)(d\omega / d\mu)|_{\omega = \omega^*} + \tilde{\omega}^*_q / \tilde{\omega}^*_q \). The corollary follows because the first term is zero (due to the envelope theorem) while the second term is positive (see Eq. (15)). \( \square \)

References


