Pay Convexity, Earnings Manipulation, and Project Continuation

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ABSTRACT: This paper studies the optimal design of long-term executive pay plans when boards of directors use accounting information for investment decision-making and executives can take costly actions to manipulate this information. The model predicts that a shift to more convex executive pay plans, such as equity plans that rely more on options and less on stock, is associated with higher levels of manipulation, lower reporting quality, and less efficient investment. When designing the optimal contract, the board trades off these effects with the cost of inducing executive effort. The paper also analyzes how the optimal pay convexity and the equilibrium level of manipulation change when the CEO’s opportunistic reporting discretion changes. The model predicts that an increase in the CEO’s marginal cost of manipulation increases the optimal level of pay convexity and first increases and then decreases the magnitude of manipulation.

Keywords: pay convexity; accounting manipulation; project continuation; reporting discretion.

JEL Classifications: M12; M41; G31.

I. INTRODUCTION

Fueled by accounting scandals in the U.S. and Europe, executive compensation has come under increased public scrutiny. A widely held concern is that compensation packages fail to link executives’ wealth to long-term firm value and create incentives to engage in accounting manipulation and fraud. The incentive to manipulate can arise because executives are free to unload equity compensation in the short run at possibly inflated prices or because executive pay is directly tied to the interim report (Crocker and Slemrod 2007). Given these imperfections in long-term contracting, one way to mitigate manipulation incentives is to reduce the incentive strength of the contract, which comes at the cost of weaker effort incentives.

I focus on another reason for why executive compensation can affect manipulation incentives, and this effect persists even when the board designs optimal long-term contracts. The CEO’s desire...
to manipulate arises because the board of directors optimally relies on accounting information for decision-making, and the optimal pay plan endogenously creates a wedge between the CEO’s and the board’s preferred decision. In this setting, the magnitude of manipulation depends on both the incentive strength of the pay plan and its convexity. The model generates new insights on how a change in the CEO’s opportunistic reporting discretion affects the optimal level of pay convexity, the magnitude of manipulation, the quality of reporting, and the efficiency of investment decisions.

In particular, the board of directors hires a CEO to work on a new project and, based on an interim accounting report, decides whether to continue or terminate the project. A crucial feature of the model is that the CEO can engage in costly manipulative activities to distort the accounting signal in his favor. Manipulation reduces the information content of the report and, hence, the efficiency of the continuation decision. The board, therefore, faces a multi-task agency problem (Holmstrom and Milgrom 1991), in which it must motivate productive effort and discourage costly manipulation.

The model predicts that both the size of the pay package and its convexity determine incentives for manipulation and, hence, reporting quality and investment efficiency. Although the optimal contract conditions pay on long-term firm performance, pay is still indirectly linked to the interim accounting report because the board uses the report to decide whether to approve project continuation. Using highly convex pay plans as a means to encourage effort increases the CEO’s desire to continue risky projects, which creates a corresponding incentive to manipulate unfavorable information. Conversely, a less convex pay plan reduces the CEO’s overinvestment bias and thereby the temptation to manipulate.

By choosing a pay plan with a sufficiently low convexity, the board could fully eliminate manipulation incentives while retaining incentives to work hard. However, such a contract is generally not optimal because the convexity of the pay plan also affects the cost of inducing effort. Specifically, if the magnitude of manipulation is exogenous, then convex pay plans are desirable because they ensure that the manager is rewarded for high performance only, which is the most effective way to induce effort. However, in the present context, this argument is incomplete because manipulation is endogenous. Greater pay convexity increases the magnitude of manipulation, which aggravates the effort incentive problem. This second, indirect effect can be strong enough to dominate the first, direct effect, but only for very high levels of pay convexity. As a consequence, there exists a unique level of pay convexity that minimizes the cost of compensation, and this level is greater than the one that minimizes manipulation. When designing the contract, the board balances the cost of compensation against the cost of inefficient investment decisions.

The paper also studies how the CEO’s opportunistic reporting discretion affects the optimal design of the incentive pay plan and the equilibrium level of manipulation. Reporting discretion plays an important role because it determines the CEO’s marginal cost of manipulating the report. When the CEO has less discretion, accounting manipulation becomes more difficult. Managerial reporting discretion is a function of the firm’s corporate governance structures, the tightness of accounting standards and their legal enforcement, as well as firm characteristics that determine the difficulty with which outsiders can oversee financial reporting. To analyze the effect of the CEO’s reporting discretion on the optimal pay plan and the equilibrium level of manipulation and investment efficiency, I distinguish between two cases.

1 A large and growing empirical literature analyzes the role of financial reporting in corporate governance. This research argues that boards monitor management and ratify key decisions and that the financial reporting system is a critical source of information to perform these tasks. For an overview of this literature, see Bushman and Smith (2001), Armstrong, Guay, and Weber (2010b), and Brickley and Zimmerman (2010).

2 This result is consistent with empirical evidence by McNichols and Stubben (2008), who find a positive relation between earnings manipulation and overinvestment in firms.
First, when opportunistic reporting discretion is limited, the board is less concerned about potential manipulation, and the optimal contract is highly convex. Although the board could further reduce manipulation incentives by reducing the convexity of the pay plan, doing so is not optimal here because it would significantly increase the cost of compensation. In this situation, a further reduction in the CEO’s reporting discretion leads to even less manipulation, which, in turn, increases reporting quality, investment efficiency, and shareholder value, consistent with conventional views.

Second, when the CEO has broad reporting discretion, the use of highly convex pay plans creates severe manipulation incentives. Manipulation is costly not only because it distorts the continuation decision, but also because it aggravates the effort control problem and leads to excessive CEO compensation. Consequently, the board combats manipulation incentives by lowering the level of pay convexity. For example, the optimal contract can be implemented through an equity grant with long vesting terms, consisting of a mix of stock and options. The lower the desired level of convexity, the higher the stock-to-option ratio in the equity plan.

As in the first case, restricting discretion directly reduces manipulation incentives. However, there is also an indirect effect because the board responds to a reduction in managerial discretion by increasing the convexity of the pay plan, which increases manipulation incentives. This indirect effect dominates the direct effect such that a lower degree of reporting discretion increases the magnitude of manipulation and reduces reporting quality. Intuitively, when designing the contract, the board balances (1) the cost of inducing effort with (2) the benefit of efficient investment decisions. When the CEO’s reporting discretion declines, the board shifts attention away from goal (2) toward goal (1). As a result, the optimal pay plan becomes more convex, which results in a lower compensation cost and greater shareholder value, but also greater manipulation and less efficient investment.

Coupling these two cases shows that the level of manipulation in organizations is an inverted U-shaped function of the CEO’s reporting discretion. In firms and countries in which governance controls are weak (strong), taking steps to improve governance increases (reduces) the magnitude of manipulation. Heightened manipulation, in turn, reduces reporting quality and the efficiency of the investment decision. The model also generates predictions that relate managerial reporting discretion to the optimal convexity of CEO compensation. Specifically, the model predicts that in firms and countries with strong governance, executive compensation packages feature more options and less stock than in firms and countries with weak governance.

Section II discusses related studies. Section III outlines the model, and Section IV presents the board’s optimization problem and two benchmark cases. Sections V and VI analyze how changes in the convexity of the pay plan affect the CEO’s manipulation incentive and the cost of inducing productive effort. Section VII determines the optimal contract and conducts a comparative static analysis. Section VIII discusses the empirical implications of the model, and Section IX concludes. All proofs are in Appendix A.

II. RELATED LITERATURE

Studies that analyze accounting manipulation in the context of agency models include Dye (1988), Feltham and Xie (1994), Goldman and Slezak (2006), Dutta and Gigler (2002), Crocker and Slemrod (2007), and Laux and Laux (2009). This line of research focuses on settings in which executive pay can only be linked to an interim performance measure that is subject to manipulation, such as earnings, but cannot be conditioned on actual long-term firm performance. In such a setting, encouraging productive effort and simultaneously eliminating incentives to manipulate the report on which pay is based is impossible. One common prediction of this literature is that the magnitude of manipulation is an increasing function of the size of the incentive package. The present paper departs from this literature.
by considering a setting in which (1) the board makes an interim investment decision based on the accounting report, and (2) CEO pay can be conditioned on the firm’s long-term performance.

Ewert and Wagenhofer (2005) also study the effects of tighter accounting standards, but in a setting in which executive compensation is exogenously given. They focus on the substitution effect between accounting and real earnings management that arises endogenously from increased value relevance.

In the above studies, communication between the CEO and the board is constrained because manipulation is associated with a personal cost to the CEO. In contrast, Evans and Sridhar (1996) restrict communication by assuming that the manager’s report must lie in a certain range and that only the manager can observe this range. They derive conditions under which designing a contract that induces truth-telling is optimal and under which tolerating manipulation is optimal. Arya, Glover, and Sunder (1998) study a setting in which communication is unrestricted, but the board’s ability to make commitments regarding CEO turnover is limited.3 They show that allowing the CEO to delay information through earnings management can be ex ante optimal because it enables the board to implement a less aggressive replacement policy. Kumar and Langberg (2009) study a capital budgeting setting in which the manager has private information about the optimal level of investment and prefers larger investments because of private benefits of control. They show that if the board is unable to commit to a certain investment policy, then inducing randomized reporting, which entails misreporting, can be optimal because it mitigates the commitment problem. In contrast, commitment plays no role in the current setting because the ex post optimal investment decision is also ex ante optimal (see discussion in Section III).

The multi-task conflict studied here is also related to models that consider the dual problem of inducing effort and efficient interim decision-making, which include Lambert (1986), Demski and Sappington (1987), and Levitt and Snyder (1997).4 In these settings, the manager receives private information that is useful for the investment decision after making an effort choice, but there is no publicly observed signal. Thus, the only tool the board has available for controlling investment decisions is the incentive pay plan. The present paper extends this literature by introducing a verifiable accounting report that is useful for controlling the investment decision and for incentive contracting, but that the CEO can manipulate through costly actions. The model provides novel insights into how the CEO’s opportunistic reporting discretion affects the convexity of the optimal pay plan, the magnitude of manipulation, the quality of financial reporting, and the investment efficiency.

III. THE MODEL

Consider a setting with two risk-neutral parties: a board of directors and a CEO. The board represents the interests of shareholders and is responsible for designing the incentive contract for the CEO and making an interim project continuation decision.

Effort

The board hires the CEO to work on a new project and offers him a pay plan, as described below. After the CEO signs the contract, he chooses an unobservable action, \( a = \{a_L, a_H\} \), with \( a_H > a_L \), that positively influences the future outcome of the project. There are two states of the world, \( S = S_L \) and \( S = S_H \). With some abuse of notation, the action \( a \) determines the probability that the good state, \( S_H \), occurs. Thus, when the CEO chooses action \( a \), the state of the world is good, \( S = S_H \), with probability \( a \), and

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3 Arya et al. (1998) also provide a good overview of related studies.

4 See, also, Inderst and Klein (2007), Inderst and Ottaviani (2009), and Laux (2014). Von Thadden (1995) studies a setting without interim private information, but in which the entrepreneur distorts the initial investment decision to increase the probability of obtaining refinancing at an interim stage.
bad, $S = S_L$, with probability $(1 - a)$. The state realization is not publicly observable and, hence, cannot be used for contracting. The CEO’s private cost associated with action $a$ is $v(a)$, where $v(a_H) = K$ and $v(a_L) = 0$. To avoid trivial solutions, I assume that the board always wishes to induce the high action.

**Cash Flows**

At an interim date, the board chooses whether to continue or terminate the project. If the project is continued, then it either succeeds and generates high cash flows, $x = x_H > 0$, or fails and generates low cash flows, $x = x_L = 0$. The probability of success is $p_H \in (0, 1]$ if the state is good and $p_L \in (0, 1)$ if the state is bad, with $p_H > p_L$. If the project is terminated, then cash flows are a constant, $x = x_M$, with $x_H > x_M > 0$. Suppose that the Pareto-efficient decision is to continue the project if $S = S_H$ and to abandon it otherwise; $p_H x_H > x_M > p_L x_H$.

**Reporting**

Prior to the continuation decision, the accounting system produces a public report, $R \in \{R_L, R_H\}$. In the absence of manipulation, the accounting report is perfectly informative about the state, and $R = R_L$ when $S = S_L$, where $j = L, H$. However, after privately observing the state, the manager can exert manipulation effort, $m$, in an attempt to distort the report. If manipulation is successful, then the accounting system reports $R = R_L$ when, in fact, $S = S_L$, with $i \neq j$ and $i, j = L, H$. The manipulation attempt is successful with probability $m$ and unsuccessful with probability $(1 - m)$. Choosing a positive level of manipulation involves a personal cost of $0.5 km^2$ for the CEO, with $k \geq 0$. The marginal cost of manipulation $k$ is determined by the CEO’s financial reporting discretion. As reporting discretion declines, successfully manipulating the report becomes more costly for the CEO.5

**Investment**

After the accounting report is issued, the board decides whether to continue or to terminate the project.6 As demonstrated later, the CEO never manipulates the report downward. Thus, if the accounting report is unfavorable, then the board knows that the state is bad, $Pr(S_L | R_L) = 1$, and optimally terminates the project, given $p_L x_H < x_M$.7

If the report is favorable, $R = R_H$, then the board is unsure whether the state is good or whether the report has been manipulated. Conditional on observing $R_H$, the probability of the good state is:

$$
\rho(m^*) = Pr(S_H | R_H, m^*) = \frac{a_H}{a_H + (1 - a_H)m^*},
$$

which is decreasing in the equilibrium level of manipulation, $m^*$. Consequently, the information

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5 Alternatively, one could assume that the report is distorted with probability $qm \in [0, 1]$ and undistorted with probability $(1 - qm)$, where $q \in [0, 1]$ is a measure of the effectiveness of manipulation. Focusing on the parameter $q$ instead of $k$ does not qualitatively change any of the results.

6 Alternatively, the model can be interpreted as a debt contracting setting, in which the firm either raises capital from creditors to continue the project or has already raised capital so that creditors have control over the abandonment/continuation decision through debt covenants. In these cases, the accounting report guides creditors’ decision about whether to fund the project continuation or, in case of debt covenants, determines whether the right to decide to abandon the project is transferred to creditors. Additional agency conflicts might arise between shareholders and creditors in these settings because shareholders might wish to privately motivate executives to take certain actions that are harmful to creditors. However, this issue can be avoided if the CEO’s pay plan is publicly observable. For example, the Securities and Exchange Commission (SEC) requires public disclosure of executive compensation information in proxy statements.

7 I assume that in equilibrium CEO compensation is not too large relative to cash flows, such that the compensation contract has no effect on the board’s ex post optimal continuation/termination decision. This is the case if the cost of effort, $K$, which determines the magnitudes of CEO payments, is not too large relative to the cash flows, $x_H$ and $x_M$. 

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The Accounting Review
November 2014
content of the favorable report declines with \( m^* \). For \( m^* = 1 \), a good report is no longer informative about the state, and the posterior probability equals the prior \( \rho(1) = a_H \).

Conditional on a favorable report, the expected cash flow associated with continuing the project is:

\[
ECF = \left[ \rho(m^*) p_H + \left( 1 - \rho(m^*) \right) p_L \right] x_H,
\]

which can be rewritten as:

\[
ECF = \left( \frac{a_H (p_H - p_L)}{a_H + (1 - a_H) m^* + p_L} \right) x_H. \tag{1}
\]

To ensure that the report is relevant to the continuation decision, I assume that continuing the project is \textit{ex post} optimal when the report is favorable, \( ECF > x_M \). A sufficient condition for \( ECF > x_M \) is that the \textit{ex ante} net present value (NPV) of the project is positive \( (a_H p_H + (1 - a_H) p_L) x_H > x_M \). If so, then \( ECF > x_M \), regardless of the level of manipulation. Intuitively, even if the manager always misrepresents bad news \( (m = 1) \), it remains optimal to continue the project for \( R = R_H \) because the unconditional NPV of the project is positive.

Note that \( ECF > x_M \) holds even when the unconditional NPV of the project is negative, as long as the equilibrium level of manipulation, \( m^* \), is not too high. However, if the unconditional NPV is negative and \( m^* \) is very high, then the board optimally might terminate the project when the report is good, \( ECF < x_M \). If this case arises, then the project is always abandoned, regardless of the report, and the model becomes trivial.

Since \( ECF > x_M \), the \textit{ex post} optimal strategy is to continue the project when \( R = R_H \) and to terminate it when \( R = R_L \). This investment policy is optimal, not only \textit{ex post}, but also \textit{ex ante}.\(^8\) Specifically, suppose that at the time of contracting, the board commits to continue the project with probability \( q_H \in [0,1] \) (\( q_L \in [0,1] \)) if the interim report is good (bad). Then, setting \( q_H = 1 \) and \( q_L = 0 \) is \textit{ex ante} optimal, as well as \textit{ex post} optimal. The basic intuition behind this result is as follows. When the board can commit to a specific investment policy, it can use different mechanisms to curb manipulation. Indeed, one way to reduce manipulation is to promise to continue the project even when the report is bad, \( q_L > 0 \), and to reward the CEO for subsequent success. All else being equal, when \( q_L \) is larger, the CEO is less concerned about issuing a bad report and, hence, manipulates less. However, an identical reduction in manipulation can be achieved by always terminating the project after an unfavorable report, \( q_L = 0 \), and by offering the CEO a bonus if the report is unfavorable (or, equivalently, a bonus for termination). Both mechanisms work equally well to mitigate manipulation incentives, but the board strictly prefers the second mechanism because it has the additional benefit of avoiding investment after observing a bad report.\(^9\)

**Manipulation and Investment**

In the reporting environment studied here, manipulation results in overinvestment and, hence, has real effects. As the equilibrium level of manipulation increases, favorable reports become less informative, and the board is more likely to approve continuation when the state is bad. Hence, by designing a contract that reduces manipulation, the board is better able to make appropriate

\(^8\) The proof is available from the author upon request.

\(^9\) When the CEO enjoys private benefits of control for project continuation, the \textit{ex post} optimal investment strategy is not necessarily \textit{ex ante} optimal, consistent with results in Kumar and Langberg (2009). This result follows because in the presence of empire benefits, promising overinvestment is a less expensive tool to mitigate manipulation in terms of compensation costs than paying a reward for termination.
investment decisions. The result that misreporting distorts real decisions is consistent with empirical
evidence by McNichols and Stubben (2008), who find a positive relation between earnings
manipulation and overinvestment in firms. Other empirical studies that find a positive link between
financial reporting quality and investment efficiency in firms are Biddle and Hilary (2006), Biddle,
Hilary, and Verdi (2009), and Chen, Hope, Li, and Wang (2011).

**Contracting**

CEO pay, \( w(R, x) \), can be made contingent on the public report \( R \in \{ R_L, R_H \} \) and the cash flow
\( x \in \{ x_H, x_M, x_L \} \). Linking pay directly to the termination/continuation decision is unnecessary
because pay is already tied to the report that determines the continuation decision.\(^{10}\) Given that the
project is abandoned after a bad report, three relevant payments exist: \( w(R_H, x_H) \), \( w(R_H, x_L) \), and
\( w(R_L, x_M) \). For convenience, let \( w_H = w(R_H, x_H) \) and \( w_L = w(R_H, x_L) \) denote the payments if the
project is continued and successful or unsuccessful, respectively, and let \( w_L = w(R_L, x_M) \) denote the
pay if the interim report is low and the project is terminated. For the discussions that follow, it is
useful to define \( W_H = w(R_H) \), which is the pay if the report is high, independent of final cash flow.
Thus, the compensation contract takes the form \( W = (W_L, W_H, w_L, w_H) \), where \( W_L \) and \( W_H \) are
payments linked to the interim report and \( w_L \) and \( w_H \) are payments linked to the long-term cash
flow.\(^{11}\) The CEO has no wealth such that payments must be nonnegative, and his reservation utility
is zero.

**Firm Value**

The goal of the board is to maximize ex ante firm value:

\[
U^{Board} = a_H p_H x_H + (1 - a_H) \left( m p_L x_H + (1 - m) x_M \right) - V, \tag{2}
\]

where \( V \) is the cost of CEO compensation, determined in Section IV. Given high effort, the state
and, hence, the report are good with probability \( a_H \), in which case the project is implemented and
succeeds with probability \( p_H \). With probability \( (1 - a_H) \), the state is bad, and the CEO successfully
manipulates the report with probability \( m \). The project is then implemented and succeeds with
probability \( p_L \). When manipulation is not successful, the project is terminated and firm value is \( x_M \).
All else being equal, an increase in manipulation, \( m \), reduces investment efficiency and firm value.

**IV. OPTIMIZATION PROBLEM**

This section determines the CEO’s optimal actions given contract \( W \), outlines the board’s
optimization problem, and presents two benchmark cases.

**Manipulation Decision**

When the CEO observes the bad state, \( S = S_L \), and chooses not to manipulate, \( m = 0 \), the report
is unfavorable and the project is abandoned. With successful manipulation, the project is continued

\(^{10}\) The board could expand the set of contractible variables by asking the CEO to communicate his private information
about the state \( S \) through a forecast, \( T \in \{ T_L, T_H \} \), after he privately observes \( S \), but before the accounting report \( R \) is
realized. The forecast helps to deter accounting manipulation, and the accounting report can be used to instill
discipline in the CEO’s forecast (Gigler and Hemmer 2001; Dutta and Gigler 2002). However, the forecast has no
value for contracting if the CEO can observe the realization of the accounting report \( R \) before he sends his forecast \( T \).

\(^{11}\) A positive payment \( W_H \) can always be replicated by \( w_H \) and \( w_L \) and, hence, is superfluous. I nevertheless consider the
payment \( W_H \) to compare short-term contracts, where pay can only be linked to the report, and long-term contracts,
where pay can also be linked to the final outcome.
and succeeds with probability $p_L$. The CEO prefers to distort the report to continue the project if:

$$W_H + p_L w_H + (1 - p_L) w_L > W_L,$$

and the optimal level of manipulation then maximizes:

$$U^{CEO}_L(m) = m \left( W_H + p_L w_H + (1 - p_L) w_L \right) + (1 - m) W_L - 0.5 km^2. $$

Taking the first-order condition with respect to $m$ yields:\(^{12}\)

$$\left( W_H + p_L w_H + (1 - p_L) w_L \right) - km = W_L. $$

If (3) is not satisfied, then the CEO has no incentive to distort the report, and $m^* = 0$.

When the CEO observes the good state, $S = S_H$, and chooses $m = 0$, the report is favorable, $R = R_H$. The project is then continued and succeeds with probability $p_H$. The CEO has an incentive to manipulate the report downward only if:

$$W_L > W_H + p_H w_H + (1 - p_H) w_L,$$

which I show later is never the case in the optimal solution. Thus, for $S = S_H$, the CEO chooses $m = 0$, and the CEO’s expected utility is:

$$U^{CEO}_H = \left( W_H + p_H w_H + (1 - p_H) w_L \right).$$

**Effort Decision**

The CEO chooses to work hard, $a = a_H$, if the following effort incentive constraint is satisfied:

$$U^{CEO}_H - U^{CEO}_L(m^*) \geq K / (a_H - a_L),$$

which is binding in the optimal solution. The expected cost of CEO compensation, $V$, and the expected CEO rent, $U^{CEO}$, can be expressed as:

$$V = a_H U^{CEO}_H + (1 - a_H) \left( U^{CEO}_L(m) + 0.5 km^2 \right),$$

$$U^{CEO} = a_H U^{CEO}_H + (1 - a_H) U^{CEO}_L(m) - K.$$

Using the effort constraint (7), $V$ can be simplified to:

$$V = a_H K / (a_H - a_L) + U^{CEO}_L + (1 - a_H) 0.5 km^2. $$

Note that the effort control problem and the manipulation problem are not independent. If the effort control problem were absent, then the board could trivially obtain first-best by offering the CEO a fixed salary that is just high enough to satisfy his reservation utility. For a fixed salary, the CEO has no reason to manipulate the accounting report, which allows the board to make the first-best investment decision.

**The Board’s Problem**

The board chooses the pay plan $(w_L, w_H, W_L, W_H)$ that maximizes the firm value in (2) subject to the manipulation constraint (5), the effort constraint (7), and the nonnegativity constraints $w_H, w_L, W_H, W_L \geq 0$. The CEO’s participation constraint is always slack and, hence, is omitted.

Before analyzing the complete problem, I briefly study two benchmark cases.

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12 The second-order condition for a maximum is satisfied.
Benchmark A

Suppose the level of manipulation, \( m \geq 0 \), is exogenously fixed. The board can induce effort either by promising a bonus for a high interim report, \( W_H > 0 \), or by promising a bonus for a high long-term outcome, \( w_H > 0 \). For \( m = 0 \), both payments are equally effective in inducing effort. However, for \( m > 0 \), the optimal contract relies exclusively on the bonus \( w_H \) as a means to induce effort.\(^{13} \) The short-term bonus \( W_H \) is suboptimal because the CEO can obtain \( W_H \) simply by successfully misreporting bad news. In contrast, the long-term bonus \( w_H \) is paid only after project success, and the probability of success depends on the true state and, hence, on effort.

Benchmark B

Suppose contracting is restricted to be short-term in the sense that CEO pay can only be conditioned on the interim accounting report. Such a pay plan not only induces managerial effort, but also creates a desire to manipulate the report upward (Crocker and Slemrod 2007). Under short-term contracting, the board has to tolerate a certain amount of manipulation as long as it wishes to induce effort. The least expensive contract that implements effort is then:

\[
W_H = \frac{K}{(a_H - a_L)} - 0.5k(m^*)^2 \quad \text{and} \quad W_L = 0,
\]

which induces manipulation \( m^* = W_H/k \).

V. MANIPULATION INCENTIVES

Under long-term contracting, the board can reduce incentives for manipulation and simultaneously maintain effort incentives. To do so, the board modifies the short-term contract specified in (11) in two steps.

Step 1

The board ties CEO pay to long-term firm performance rather than to the interim report. This move eliminates the direct link between pay and reporting because favorable reports no longer automatically yield a bonus for the CEO. Consequently, the use of long-term performance pay not only reduces the cost of CEO compensation when manipulation, \( m > 0 \), is exogenously given, as in Benchmark A, but also reduces incentives for manipulation.

Lemma 1: The level of manipulation declines when the board relies on the long-term bonus, \( w_H \), rather than the short-term bonus, \( W_H \), as a means to induce effort. Therefore, the optimal contract sets \( w_L = W_H = 0 \). For \( W_H > 0 \) and \( W_L = 0 \), the CEO chooses a level of manipulation, \( m = m_0 > 0 \), that is determined by:

\[
\left( \frac{K}{(a_H - a_L)} + 0.5km_0^2 \right)p_L/p_H - m_0k = 0.
\]

Even when CEO pay is no longer directly linked to the interim accounting report, \( W_H = 0 \), it is still indirectly linked to the report. This indirect link occurs because the board relies on the accounting report to make the continuation decision, and high future performance is only possible when the project is continued. As a result, the use of long-term performance pay encourages the CEO to manipulate the report to influence the investment decision.

\(^{13} \) A proof is available on request.
Step 2

The board can further reduce manipulation incentives below \( m = m_0 \), given in \((12)\), by offering a bonus for a low accounting report, \( W_L > 0 \). The problem is that \( W_L \) rewards the CEO for poor performance and, hence, weakens effort incentives. To restore incentives, the board must increase the long-term bonus \( w_H \), which again increases the CEO’s temptation to manipulate the report. The important point here is that the reducing effect of \( W_L \) on manipulation dominates the increasing effect of \( w_H \) on \( m \). Formally, solving for the long-term bonus \( w_H \) determined by the effort constraint \((7)\) yields:

\[
 w_H = \frac{K}{(a_H - a_L) - 0.5km^2 + (1 - m)W_L}{(p_H - m p_L)},
\]

which confirms that \( w_H \) increases in \( W_L \). Substituting \((13)\) into the manipulation constraint \((5)\) and taking the first derivative with respect to \( W_L \) yields:

\[
 \frac{dm^*}{dW_L} = -\frac{p_H - p_L}{k(p_H - m^* p_L)} < 0.
\]

Note that an increase in \( W_L \) and the associated increase in \( w_H \) reduce the convexity of the pay plan. Given that \( w_H \) is the pay when the project is continued and successful, \( x = x_H \), and \( W_L \) is the pay when the project is terminated, \( x = x_M \), with \( x_M < x_H \), the contract is convex in outcome if:

\[
 Q(W_L) = \frac{w_H(m, W_L) - W_L}{x_H - x_M} - \frac{W_L}{x_M} > 0,
\]

where \( w_H(m, W_L) \) is determined by the effort constraint \((7)\) and \( m \) is determined by the manipulation constraint \((5)\). Obviously, for \( W_L = 0 \), the pay plan is convex, given that \( w_H > 0 \). When \( W_L \) increases, the bonus \( w_H \) increases, as well, to satisfy the effort incentive constraint, but not as quickly such that the convexity of the pay plan declines; that is, \( dQ/dW_L < 0 \). The following Proposition summarizes the results.

**Proposition 1:** The board can induce effort and simultaneously reduce the level of manipulation by increasing the payments \( W_L \) and \( w_H \), which leads to a reduction in the convexity of the pay plan, \( Q \). The reducing effect on manipulation is stronger when \( m^* \) is larger.\(^{15}\) For a sufficiently high \( W_L \), the CEO chooses \( m^* = 0 \).

As \( W_L \) decreases, the pay plan becomes more convex in outcome and the CEO has a stronger desire to continue the project, which translates into a stronger incentive to manipulate the report. Conversely, an increase in \( W_L \) lowers pay convexity and reduces the CEO’s appetite for risky projects. For a sufficiently low level of pay convexity, the CEO’s preferences regarding project continuation are perfectly aligned with those of shareholders, and the CEO no longer has any reason to distort the report and chooses \( m = 0 \). This is trivially the case if pay is linear in outcome.\(^{16}\)

**VI. COST OF COMPENSATION**

The board can mitigate the CEO’s incentive to engage in manipulation through the use of less convex pay plans. A reduction in manipulation is beneficial because it increases the accuracy of the

\(^{14}\) For details, see the proof of Proposition 1 in Appendix A.

\(^{15}\) The level of manipulation, \( m^*(k, W_L) \), is itself a function of \( k \) and \( W_L \) and is determined in \((23)\) in Appendix A.

\(^{16}\) When pay is linear in outcome, the CEO wishes to continue the project if, and only if, the expected cash flow associated with project continuation exceeds \( x_M \), which is also the shareholders’ preferred investment rule.
accounting report and thereby allows for more efficient continuation decisions. What remains to be
analyzed is how a reduction in pay convexity changes the CEO’s effort incentive and, hence, the
cost of compensation, $V$.

Taking the first derivative of (10) with respect to $W_L$ and using the effort and manipulation
constraints (7) and (5) yields:

$$\frac{dV}{dW_L} = \left(1 - m^* \frac{p_H - p_L}{p_H - m^* p_L}\right) + \left(\frac{dm^*}{dW_L} km^* (1 - a_H)\right),$$

(16)

where $\frac{dm^*}{dW_L}$ is given in (14).

An increase in $W_L$ and the associated increase in $w_H$ reduce the convexity of the pay plan, $Q$. Offering a less convex pay plan affects the cost of inducing effort, $V$, through two channels. To
discuss the first channel, suppose for a moment that the level of manipulation, $m \geq 0$, is exogenously
fixed. Given that the manager is risk-neutral, pay convexity is desirable because it ensures that the
CEO is rewarded for high performance only. Such a pay plan is most effective in inducing effort and, hence, lowers the cost of compensation. In contrast, if the board increases $W_L$ to reduce pay convexity, then the CEO obtains a reward even for poor performance. For a fixed level of manipulation, rewarding poor performance is never optimal because it dilutes effort incentives and increases the cost
of compensation. This effect is captured in the first term in (16).17 However, the level of manipulation
is not fixed, but decreases with $W_L$, as established in Proposition 1. As $W_L$ increases, pay convexity
and, hence, incentives for manipulation decline. The reduction in manipulation, in turn, makes
inducing effort easier and reduces the cost of compensation. This effect is captured in the second term
in brackets in (16) and can be strong enough to dominate the first effect, implying that an increase in
$W_L$ can reduce the cost of compensation.

Coupling these effects shows that the relation between $W_L$ and the cost of compensation can either be positive, negative, or zero. The sign and strength of this relation depend on the level of
manipulation, $m^*(k, W_L)$, which is itself a function of $W_L$ and the reporting discretion, represented
by $k$, (see (23) in Appendix A).18

**Proposition 2:** Suppose that $k > 0$. There exists a unique interior threshold,

$$m_T = \frac{p_H + (p_H - p_L)(1 - a_H)}{p_H + (p_H - p_L)}$$

such that a marginal increase in $W_L$:

(i) decreases the expected cost of compensation, $V$, if $m^*(k, W_L) > m_T$, and

(ii) increases $V$, if $m^*(k, W_L) < m_T$, and

(iii) has no effect on $V$, if $m^*(k, W_L) = m_T$.

Given that the magnitude of manipulation decreases as the pay $W_L$ increases, Proposition 2
implies that the cost of inducing effort, $V$, is a convex function of $W_L$.

**Corollary 1:** Suppose that $k > 0$. The expected cost of compensation, $V$, is strictly convex in
$W_L$, such that a unique level of $W_L$ exists that minimizes $V$.

**VII. OPTIMAL CONTRACT AND COMPARATIVE STATICS**

In this section, I determine the optimal contract and conduct a comparative statics analysis. To
establish a useful benchmark, I start with the special case in which the CEO can costlessly
manipulate the report, $k = 0$. I then analyze the case in which the CEO has limited discretion, in the

17 If the level of manipulation is fixed at $m = 0$, then a one-to-one relation exists between $W_L$ and CEO rents.
18 Note that $\frac{dm^*}{dk}(k, W_L) < 0$ and $\frac{dm^*}{dW_L} < 0$.
sense that $k$ lies above a certain threshold, denoted $k_T$, and the case in which he has broad discretion, in the sense that $k < k_T$.

**No Manipulation Cost ($k = 0$)**

When the CEO’s cost of misreporting is zero, $k = 0$, he faces no reporting restrictions, which is equivalent to assuming that there is no public signal.

**Proposition 3:** When the CEO has unlimited reporting discretion, $k = 0$, the optimal pay plan eliminates manipulation, $m^* = 0$, and is given by:

$$
\begin{align*}
    w_H^* &= K / (a_H - a_L) \\
    &+ (p_H - p_L) \\
    W_L' &= p_L K / (a_H - a_L) \\
    &+ (p_H - p_L).
\end{align*}
$$

For $k = 0$, the manager’s reporting choice is a corner solution: He either always misreports bad news, $m = 1$, or never misreports, $m = 0$. Suppose for the moment the pay plan is such that the CEO prefers project continuation when the state is bad, $p_L W_H > W_L$. The CEO will then always misreport, $m = 1$, to ensure continuation and to receive the expected pay $p_L W_H$. But the board can eliminate misreporting incentives by offering the exact same amount for project abandonment, $W_L = p_L W_H$. Such a contract is as costly as the one that induces manipulation, but is strictly preferred because it leads to truthful reporting and, hence, to first-best investment. Consequently, for $k = 0$, it is always optimal to eliminate misreporting incentives, $m^* = 0$, and to implement the first-best continuation decision.

**Limited Reporting Discretion**

Consider now an environment in which the CEO has limited reporting discretion, $k > k_T$, where $k_T$ is defined in Appendix A. The CEO’s manipulation opportunities are restricted and the level of $m$ is small even when the board sets $W_L = 0$. The board can further mitigate manipulation incentives and thereby improve the continuation decision by increasing the pay $W_L$, which reduces pay convexity. However, we know from Proposition 1 that this effect is weak when $m^*$ is small. In addition, for small $m^*$, an increase in $W_L$ strongly increases the cost of compensation, $V$ (Proposition 2). Hence, the increase in compensation cost outweighs the benefit of a better investment decision, and the board optimally sets $W_L = 0$.

**Proposition 4:** When the CEO has limited reporting discretion, $k > k_T$, the board does not control manipulation through pay convexity, and the optimal contract is:

$$
\begin{align*}
    w_H^* &= \left( K / (a_H - a_L) + 0.5 k m_0^2 \right) / p_H \\
    W_L &= 0.
\end{align*}
$$

The equilibrium level of manipulation is $m^* = m_0$, which is given in (12).

In this situation, a further reduction in reporting discretion reduces the level of manipulation and improves reporting quality and investment efficiency, consistent with conventional views. In addition, a lower discretion reduces the rent the CEO can obtain when the state is bad and, hence, relaxes the effort incentive problem. As a consequence, the bonus $w_H$ required to motivate effort declines with $k$, resulting in a lower expected cost of compensation. These effects directly imply that shareholder value increases when opportunistic reporting discretion declines. The next proposition summarizes the results.

**Proposition 5:** Suppose that $k > k_T$. When $k$ increases,

(i) the level of manipulation, $m^*$, declines, leading to more efficient continuation decisions;

(ii) the bonus $w_H$ declines; and
(iii) shareholder value, $U^{Board}$, increases, and the CEO’s expected compensation, $V$, and rent, $U^{CEO}$, decrease.

**Broad Reporting Discretion**

Consider now an environment in which the CEO has broad reporting discretion, $k < k_T$. For a highly convex pay plan, $W_L = 0$, the CEO has strong incentives to engage in manipulation. From Proposition 1, we know that an increase in $W_L$ lowers the level of manipulation and improves the investment decision, and this effect is stronger when $m^*$ is high. In addition, from Proposition 2, an increase in $W_L$ either mildly increases or even reduces the cost of compensation for high $m^*$. As a consequence, for $k < k_T$, the board finds it optimal to curb manipulation incentives through the incentive pay plan and sets $W_L > 0$. The optimal level of $W_L$ balances the two goals of minimizing the cost of inducing effort and implementing efficient abandonment decisions.

**Proposition 6:** When the CEO has broad reporting discretion, $k < k_T$, the board controls manipulation incentives through pay convexity, and the optimal contract is:

$$w^*_H(m) = \frac{K}{(a_H - a_L) - km + 0.5km^2} > 0, \quad (18)$$

$$W^*_L(m) = \frac{p_L \left( \frac{K}{(a_H - a_L)} + 0.5km^2 \right) - kmp_H}{(p_H - p_L)} > 0. \quad (19)$$

The equilibrium level of manipulation, $m^*$, satisfies:

$$m^* = \max \left\{ 0, \frac{-(1 - a_H)(p_H - p_L)(x_M - p_Lx_H) + p_Hk}{k \left( (1 - a_H)(p_H - p_L) + p_H \right)} \right\}. \quad (20)$$

As in the previous case, a reduction in managerial discretion directly reduces manipulation incentives. However, an indirect effect also arises because the board responds to the change in discretion by reducing the pay $W_L$, which increases manipulation incentives. This indirect effect dominates the direct effect, such that lower levels of reporting discretion increase the magnitude of manipulation and reduce reporting quality. To see the intuition, note that the board can always react to an increase in $k$ by choosing a lower $W_L$, such that the level of manipulation remains unchanged. But the board can do better by reducing $W_L$ even further, which pushes the level of manipulation above the previous level. This approach is optimal because when manipulation is more costly for the CEO, a change in $W_L$ has a weaker effect on the CEO’s manipulation choice and a stronger effect on the cost of compensation. As a result, the optimal pay plan becomes more convex, which results in a lower compensation cost and greater shareholder value, but also greater manipulation and less efficient investment.

**Proposition 7:** Suppose that $k < k_T$. When $k$ increases:

(i) the level of manipulation, $m^*$, increases, leading to less efficient continuation decisions;

(ii) both $W_L$ and $w_H$ decline, and the optimal pay plan becomes more convex; and

---

19 Note that condition (20) implies that $m^* < 1$. Condition (20) also confirms the result from Proposition 3. When the CEO has full reporting discretion (i.e., when $k$ approaches zero), the fraction in (20) becomes negative, implying that $m^* = 0$.

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(iii) shareholder value, $U_{\text{Board}}$, increases, and the CEO’s expected compensation, $V$, and rent, $U_{\text{CEO}}$, decrease.

Propositions (5) and (7) directly lead to the next corollary.

**Corollary 2:** The level of manipulation is an inverted U-shaped function of managerial reporting discretion, $k$. 

The plots in Figures 1, 2, and 3 depict the level of manipulation, firm value, and cost of compensation as a function of the quality of corporate governance, $k$, for the parameters $a_H = 0.7$, $a_L = 0.2$, $K = 60$, $p_H = 0.9$, $p_L = 0.2$, $x_H = 1,200$, and $x_M = 300$.

**VIII. DISCUSSION AND EMPIRICAL PREDICTIONS**

**Equity Contract**

The board can implement the optimal incentive contract derived in Section VII using an equity pay plan that consists of stock and options. As the desired level of pay convexity increases (decreases), the optimal equity mix shifts in favor of options (stock).\(^{20}\) The plot in Figure 4 depicts the optimal equity combination as a function of the governance quality, $k$, for the parameters introduced in the previous section.\(^{21}\)

\(^{20}\) For details, see the proof of Propositions 4 and 6 in Appendix A. \textit{Kadan and Swinkels (2008)} study a setting without investment and accounting manipulation and find that the optimal equity contract consists either solely of stock or solely of options, depending on the firm’s bankruptcy risk.

\(^{21}\) In the figure, the equity mix is presented as $\beta_O(\beta_O + \beta_S)$, which is 1 (0) if the optimal contract involves only options (stock).
Note that the optimal contract prohibits the CEO from unloading his equity before final cash flows are realized, for example, by awarding equity grants with long vesting periods. Otherwise, if the CEO is free to unload his equity holdings in the short run, then he can capture a positive payoff after issuing a favorable report. Given that this payoff is independent of the project’s long-term outcome, early vesting provisions contradict $w^*_L = W^*_H = 0$.

**Equity Mix and Manipulation**

In recent years, equity-based compensation has been criticized for encouraging executives to engage in accounting manipulation and fraud. A motive for manipulation arises because executives can reap personal gains by boosting accounting numbers and cashing out equity at inflated prices. However, this argument applies only for vested equity that the CEO is free to unload (Core 2010). Larger equity awards that can be unloaded in the short run are, therefore, suspected to cause larger levels of manipulation and fraud. The empirical evidence on this relation has produced inconclusive results (Bergstresser and Philippon 2006; Burns and Kedia 2006; Erickson, Hanlon, and Maydew 2006; Johnson, Ryan, and Tian 2009; Armstrong, Jagolinzer, and Larcker 2010a).22

The current model shows that even long-term equity pay that cannot be cashed out in the short run can cause executives to manipulate interim accounting reports. The desire to misreport arises because the board relies on the accounting report for decision-making, and the optimal pay plan creates a wedge between the CEO’s and the board’s preferred decision. Manipulation is costly for shareholders not only because it increases expected CEO pay, but also because it leads to inefficient investment decisions.

22 Most of the empirical studies focus on the relation between equity delta, which measures the sensitivity of managers’ wealth to changes in stock price, and misreporting. In contrast, Armstrong, Larcker, Ormazabal, and Taylor (2013) focus on equity Vega, which measures the sensitivity of managers’ wealth to stock return volatility. They find a positive relation between Vega and misreporting and no relation between delta and misreporting, when controlling for Vega.
The model demonstrates that the incentive to distort accounting information depends on both the size of the equity package and the mix of stock and options (pay convexity). When the equity contract puts greater emphasis on options relative to stock, the convexity of the contract increases and the CEO has a stronger incentive to engage in manipulation to prevent project abandonment. The model predicts that equity pay packages with smaller stock-to-option ratios are associated with higher levels of accounting manipulation and with lower reporting quality and investment efficiency.

**FIGURE 3**
Compensation Cost and Governance

**FIGURE 4**
Equity Mix, $\beta_O/(\beta_O + \beta_S)$, and Governance
Reporting Discretion and Manipulation

An important factor that determines both the equilibrium level of manipulation and the optimal choice of pay convexity is the CEO’s opportunistic reporting discretion, captured by the variable $k$ in the model. Reporting discretion is a function of the firm’s corporate governance structures, the tightness of accounting standards and their legal enforcement, and firm characteristics that determine the difficulty with which outsiders can oversee financial reporting, such as firm size and complexity of operations. There is a large and growing number of empirical studies analyzing the effects of governance mechanisms or accounting standards on reporting quality (Dechow, Sloan, and Sweeney 1996; Beasley 1996; Klein 2002; Farber 2005; Larcker, Richardson, and Tuna 2007; Barth, Landsman, and Lang 2008; Jeanjean and Stolowy 2008). The empirical evidence thus far, however, has not produced a consistent set of results.

The present model shows that changes in the level of reporting discretion affect incentives for accounting manipulation not only directly, but also indirectly through the optimal design of the incentive pay plan. For this reason, and as demonstrated in Corollary 2, the level of manipulation in firms is an inverted U-shaped function of managerial reporting discretion. This result has the following two empirical implications.

First, the model suggests that the effect of changes in the firm’s financial reporting environment on the prevalence of manipulation depends on whether executives initially have broad or limited reporting discretion. Specifically, in firms and countries in which governance controls are weak, taking steps to improve governance actually increases the magnitude of manipulation. An increase in manipulation, in turn, reduces reporting quality and investment efficiency. In contrast, in firms and countries in which governance is strong, further improvements in governance reduce the magnitude of manipulation, consistent with conventional views.

Second, the model suggests that the observed reporting quality in corporations is not a good indicator of the quality of the financial reporting environment. To elaborate, consider empirical studies that observe that the transition from local generally accepted accounting principles (GAAP) to international financial reporting standards (IFRS) reporting is associated with a lower level of earnings manipulation. This finding does not necessarily imply that IFRS is more effective in restricting managerial reporting discretion than local GAAP. Rather, the opposite could be true. Manipulation then declines, despite the manager’s greater freedom to misreport, because the board responds to higher reporting discretion by reducing the convexity of the pay plan.

Determinants of Optimal Pay Plan

The firm’s financial reporting environment is an important determinant of the optimal design of executive compensation. The model predicts that in firms and countries in which governance controls are weak, the stock-to-option ratio in equity packages is higher than in firms and countries in which governance is strong. In addition, assuming that directors and auditors have a harder time overseeing financial reporting in larger firms with more complex business operations, the model predicts greater use of options, relative to stock, in smaller firms than in larger firms.

Empirical studies that analyze the effects of corporate governance structures on executive pay design have focused thus far on the pay-for-performance sensitivity of executive compensation (Hartzell and Starks 2003; Fahlenbrach 2009). To the best of my knowledge, no empirical study has yet examined the link between governance measures and the convexity of executive compensation.

IX. CONCLUSION

This paper studies the optimal long-term incentive pay plan when executives can engage in costly activities to distort accounting information. Executive pay can affect manipulation incentives
for different reasons. While observers and commentators have primarily focused on manipulation incentives that follow from short-term contracting, I focus on another motive for manipulation that persists even when the board designs optimal long-term contracts. The CEO’s incentive to manipulate arises because the board uses accounting information to make investment decisions, and the optimal contract creates a wedge between the board’s and the CEO’s preferred decision. In such a setting, the desire to manipulate depends not only on the strength of the pay plan, but also on its convexity. As the pay plan becomes more convex, the CEO has a stronger desire to continue the project and, hence, a stronger incentive to manipulate the report to distort the investment decision. The model predicts that higher pay convexity is associated with higher levels of manipulation, as well as lower reporting quality and investment efficiency. Although designing a pay plan that eliminates manipulation and simultaneously induces productive effort is possible, the model demonstrates that doing so is generally not optimal. Instead, the board tolerates some manipulation to keep the cost of the pay plan low.

An important determinant of both the optimal incentive pay plan and the magnitude of manipulation is the financial reporting environment. The analysis shows that the level of manipulation in organizations is an inverted U-shaped function of the CEO’s opportunistic reporting discretion. The model predicts that in firms and countries in which governance controls are weak (strong), taking steps to improve governance increases (reduces) the magnitude of manipulation and reduces (increases) the reporting quality and investment efficiency. In addition, the model predicts that in firms and countries with strong governance, the stock-to-option ratio in equity packages is lower than in firms and countries with weak governance.

REFERENCES


APPENDIX A
Proofs

Proof of Lemma 1
The proofs of Propositions 4 and 6 show that setting $w_L = W_H = 0$ is optimal. Here, I demonstrate that the level of manipulation increases when the board relies on $W_H$ rather than $w_H$ to implement effort. Rearranging the effort constraint (7) yields:

$$w_H = \frac{K/(a_H - a_L) - 0.5km^2 - (1 - m)(W_H - W_L + w_L)}{(p_H - p_L)m) + w_L, \quad (21)$$

which shows that the level of $w_H$ required to induce effort declines with $W_H$. Substituting (21) into the manipulation constraint (5) and setting $W_L = w_L = 0$ yields:

$$W_H(p_H - p_L) + p_L\left(K/(a_H - a_L) - 0.5km^2\right)/\left(p_H - p_Lm\right) - km = 0. \quad (22)$$

Using the implicit function theorem on (22) gives:

$$\frac{dm}{dW_H} = \frac{p_H - p_L}{(p_H - m_p)k} > 0.$$ 

Proof of Proposition 1
Substituting the effort incentive constraint (7) into (5) and setting $W_H = w_L = 0$ yields:

$$p_L\frac{K/(a_H - a_L) + (1 - m)W_L - 0.5km^2}{(p_H - p_Lm)} - km = W_L, \quad (23)$$

which determines the equilibrium level of manipulation as a function of $W_L$. Using the implicit function theorem on (23), we obtain:

$$\frac{dm}{dW_L} = -\frac{p_L(1 - m) - (p_H - p_Lm)}{-(p_LW_L + kp_H) + p_L\frac{K/(a_H - a_L) + (1 - m)W_L - 0.5km^2}{(p_H - p_Lm)}},$$

which, using (23), can be written as:

$$\frac{dm}{dW_L} = -\frac{p_H - p_L}{k(p_H - p_L)m}. \quad \frac{d^2m}{dW_Ldm} = -\frac{p_L(p_H - p_L)}{k(p_H - p_Lm)^2} < 0,$
showing that the reducing effect of $W_L$ on $m$ is stronger when the equilibrium level of manipulation is higher.

An increase in $W_L$ and the associated increase in $w_H$ reduce the convexity of the pay plan, $Q(W_L)$, given in (15). To see this, we can rearrange the effort constraint (7) and set $W_H = w_L = 0$ to obtain:

$$w_H = \frac{K}{p_H - mp_L} + W_L(1 - m) - 0.5km^2.$$  \hspace{1cm} (24)

It follows that:

$$\frac{\partial w_H}{\partial m} = - \frac{(km + W_L)}{p_H - mp_L} + \frac{p_L w_H}{(p_H - mp_L)} = 0,$$  \hspace{1cm} (25)

which is zero because of the manipulation constraint (5). Using:

$$\frac{dw_H(W_L, m)}{dW_L} = \frac{\partial w_H}{\partial W_L} + \frac{\partial w_H}{\partial m} \frac{dm}{dW_L} = \frac{(1 - m)}{p_H - mp_L},$$  \hspace{1cm} (26)

and taking the first derivative of (15) yields:

$$\frac{dQ}{dW_L} = \frac{\partial Q}{\partial W_L} + \frac{\partial Q}{\partial w_H} \frac{dw_H}{dW_L} = \frac{\partial Q}{\partial W_L} + \frac{\partial Q}{\partial W_H} \frac{dw_H}{dW_L} = \frac{1}{x_H - x_M} - \frac{1}{x_M} = - \frac{(p_H x_H - x_M) + m(x_M - x_H p_L) x_M (x_H - x_M) (p_H - mp_L)}{x_M (x_H - x_M) (p_H - mp_L)}.$$  \hspace{1cm} (27)

**Proof of Proposition 2 and Corollary 1**

After substituting (4) into (10) and setting $w_L = W_H = 0$, the cost of compensation can be written as:

$$V = a_H K / (a_H - a_L) + mp_L w_H + (1 - m) W_L - a_H 0.5km^2.$$  \hspace{1cm} (28)

Taking the first derivative with respect to $W_L$ gives:

$$\frac{dV}{dW_L} = mp_L \frac{dw_H}{dW_L} + (1 - m) + \frac{dm}{dW_L} (p_L w_H - W_L - a_H km),$$  \hspace{1cm} (29)

which, using (5), can be written as:

$$\frac{dV}{dW_L} = mp_L \frac{dw_H}{dW_L} + (1 - m) + \frac{dm}{dW_L} km(1 - a_H).$$  \hspace{1cm} (30)

Substituting (26) into (30) yields (16) in the main text. Substituting (14) into (16) yields:

$$\frac{dV}{dW_L} = 1 - m \frac{p_H - p_L}{p_H - mp_L} (2 - a_H).$$  \hspace{1cm} (31)

Observe that for $m = 0$, we have $dV/dW_L = 1 > 0$, and for $m = 1$, we have $dV/dW_L = -(1 - a_H) < 0$. Further, note that:
$$\frac{d^2V}{dW_L dm} = -p_H \frac{(2 - a_H)(p_H - p_L)}{(p_H - mp_L)^2} < 0.$$  \hspace{1cm} (32)

Hence, a unique threshold level of manipulation, $m_T$, exists such that $dV/dW > 0$ for all $m < m_T$ and such that $dV/dW_L < 0$ for all $m > m_T$.

Finally, note that:

$$\frac{d^2V}{dW_L^2} = \frac{d^2V}{dW_L dm} \frac{dm}{dW_L},$$

which is negative because $\frac{d^2V}{dW_L dm} < 0$, from (32), and $\frac{dm}{dW_L} < 0$, from (14).

**Proof of Proposition 3**

The case in which the CEO has full reporting discretion, $k = 0$, is also covered in the proofs of Propositions 4 and 6 that follow. I show here that the cost of implementing $(a = a_H, m = 1)$ is identical to the cost of implementing $(a = a_H, m = 0)$. For $k = 0$, the cost of compensation, given in (10), and the effort constraint, given in (7), simplify to:

$$V = a_H K/(a_H - a_L) + mp_L w_H + (1 - m)W_L,$$

$$w_H = \frac{K/(a_H - a_L) + (1 - m)W_L}{(p_H - p_L m)}.$$  \hspace{1cm} (34)

When $p_L w_H > W_L$, the CEO chooses $m = 1$, and the compensation cost is:

$$V(m = 1) = a_H K/(a_H - a_L) + p_L w_H,$$

with $w_H = \frac{K/(a_H - a_L)}{(p_H - p_L)}$. If $p_L w_H = W_L$, then the CEO chooses $m = 0$, and:

$$V(m = 0) = a_H K/(a_H - a_L) + W_L,$$

with $W_L = p_L w_H$ and $w_H = \frac{K/(a_H - a_L)}{(p_H - p_L)}$. Observe that $V(m = 1) = V(m = 0)$. Thus, for $k = 0$, the optimal contract implements $m^*_0 = 0$.

**Proof of Propositions 4 and 6**

The Lagrangian of the board’s optimization problem, described in Section IV, is as follows:

$$\operatorname{max} \ G = a_H p_H x_H + (1 - a_H) \left( mp_L x_H + (1 - m) x_M \right) - a_H \left( W_H + p_H w_H + (1 - p_H) w_L \right) - (1 - a_H) \left( m \left( W_H + p_L w_H + (1 - p_L) w_L \right) + (1 - m) W_L \right) + \lambda \left( \left( W_H + p_H w_H + (1 - p_H) w_L \right) - K/(a_H - a_L) \right) + \lambda \left( - \left( m \left( W_H + p_L w_H + (1 - p_L) w_L \right) + (1 - m) W_L - 0.5 km^2 \right) \right) + \mu \left( W_H + p_L w_H + (1 - p_L) w_L - mk - W_L \right),$$

where $\lambda$ is the Lagrangian multiplier associated with the effort incentive constraint (7) and $\mu$ is the multiplier associated with the manipulation constraint (5).

The necessary conditions for a solution include:

$$\frac{\partial G}{\partial w_j} \leq 0, \quad w_j \geq 0, \quad \text{and} \quad \frac{\partial G}{\partial w_j} w_j = 0 \quad \text{for} \quad j = L, H,$$
\[ \frac{\partial G}{\partial W_j} \leq 0, \quad W_j \geq 0, \quad \text{and} \quad \frac{\partial G}{\partial W_j} W_j = 0 \quad \text{for} \quad j = L, H, \]

\[ \frac{\partial G}{\partial m} \leq 0, \quad m \geq 0, \quad \text{and} \quad \frac{\partial G}{\partial m} m = 0. \]

There are two possible solutions to this problem.

**Case 1**

Assume that in the optimal solution, \( w_H > 0 \) and \( W_L > 0 \). This assumption implies that \( \frac{\partial G}{\partial w_H} = 0 \), which yields:

\[ \lambda = \frac{a_H p_H + p_L (1 - a_H)}{p_H - p_L}, \]  

(38)

\[ \mu = -\frac{1}{p_H} \frac{1 - m}{p_H - p_L}. \]  

(39)

Using (38) and (39), we obtain \( \frac{\partial G}{\partial w_H} = -1 < 0 \) and \( \frac{\partial G}{\partial w_L} = -1 < 0 \), which shows that the optimal contract sets \( W_H = w_H = 0 \).

The optimal payments \( w_H > 0 \) and \( W_L > 0 \) are determined by (5) and (7), which yields (19) and (18) in Proposition 6. Using \( W_H = w_H = 0 \), as well as (19), (18), (38), and (39), we obtain:

\[ \frac{\partial G}{\partial m} = -(1 - a_H) \left( (x_M - p_L x_H) + m k \right) + k p_H \left( \frac{1 - m}{p_H - p_L} \right). \]  

(40)

From (40), if \( k = 0 \), then \( \frac{\partial G}{\partial m} < 0 \), implying that the optimal contract implements \( m = 0 \), confirming the result in Proposition 3. Setting \( \frac{\partial G}{\partial m} = 0 \) and solving for \( m \) yields (20) in Proposition 6.

In the optimal solution, \( W_L(m) \) must be nonnegative. Note that \( W_L(m) \) is decreasing in \( m \). Hence, \( W_L(m) \geq 0 \) is satisfied if, and only if, the equilibrium level of \( m \) is smaller than the threshold level denoted \( m_A \), which is determined by:

\[ W_L(m_A) = \frac{\left( K / (a_H - a_L) + 0.5 km^2 \right) p_L - m_A p_H k}{(p_H - p_L)} = 0. \]  

(41)

**Case 2**

Assume that in the optimal solution, \( w_H > 0 \) and \( W_L = 0 \). Hence, \( \lambda \) and \( \mu \) are determined by \( \frac{\partial G}{\partial w_H} = 0 \) and \( \frac{\partial G}{\partial m} = 0 \). Let \( \lambda^S \) and \( \mu^S \) denote the solution to \( \frac{\partial G}{\partial w_H} = 0 \) and \( \frac{\partial G}{\partial m} = 0 \). Using \( \lambda = \lambda^S, \mu = \mu^S, \) (5), and \( W_L = 0 \), it can be shown that \( \frac{\partial G}{\partial w_H} < 0 \) and \( \frac{\partial G}{\partial m} < 0 \), which implies that the optimal contract sets \( W_H = 0 \) and \( w_H = 0 \).

The optimal bonus \( w_H \) and the equilibrium level of \( m \) are determined by (7) and (5) which, using \( W_L = w_L = W_H = 0 \), yields (17) and (12) in Proposition 4.

Setting \( W_L = 0 \) is only optimal if \( \frac{\partial G}{\partial W_L} \leq 0 \). Using \( \lambda = \lambda^S, \mu = \mu^S, \) (5), and \( w_L = W_H = 0 \) gives:

\[ \frac{\partial G}{\partial W_L} = \frac{(p_H - p_L)(1 - a_H) \left( km + (x_M - x_H p_L) \right) - p_H k (1 - m)}{(p_H - p_L m) k}. \]  

(42)

Condition \( \frac{\partial G}{\partial W_L} \leq 0 \) is satisfied if, and only if:
When Is Each Case Relevant?

For convenience, let $m_1^*$ and $m_2^*$ denote the equilibrium levels of manipulation for Case 1 and Case 2, which are determined by (20) and (12), respectively. Note that the right-hand side of (43) equals $m_1^*$ and that $m_2^*$ equals $m_A$, determined in (41). Thus, Case 1 applies if $m_1^* < m_2^*$ and Case 2 applies if $m_1^* > m_2^*$. Further, as shown in the proof of Propositions 5 and 7, it holds that $dm_1^*/dk > 0$ and $dm_2^*/dk < 0$. Thus, a unique threshold, $k_T$, exists that is determined by $m_1^*(k_T) = m_2^*(k_T)$, such that for all $k < k_T$, the contract in Proposition 6 is optimal, and for all $k > k_T$, the contract in Proposition 4 is optimal.

Equity Contract

The board can implement the optimal incentive contract using an equity pay plan that consists of a combination of long-term stock and options. Assume, without loss of generality, that initial shareholders hold one issued share of stock. The equity contract takes the form $(b_S, b_O, E)$, where $b_S$ and $b_O$ specify the number of restricted stock and stock options awarded to the CEO in the beginning of the game, and $E$ is the exercise price of the stock options. Suppose that $E \in [x_M, x_H)$, such that the options have a positive value only if the project is continued and successful (replicating payment $w_H$).

Note, if the CEO is free to unload equity holdings in the short run, then he can reap a positive payoff after issuing a favorable report that is independent of the project’s actual long-term cash flow. This result follows because the interim stock price that arises after observing a good report is positive and given by:

$$P(R_G) = \frac{a_H(p_H - p_L)}{(a_H + (1 - a_H)m^*) + p_L}x_H.$$  

Thus, to replicate the optimal pay plan, with $w_L = 0$ and $W_H = 0$, the contract must prohibit the CEO from unloading the equity prior to the realization of $x$, for example, by offering equity with a long vesting period.

To implement the optimal payments, $w_H > 0$ and $W_L > 0$, defined in (19) and (18), the board sets $\beta_S > 0$ and $\beta_O > 0$, such that the following two equations are satisfied:

$$W_L^* = \beta_S x_M,$n
$$w_H^* = \beta_S x_H + \beta_O (x_H - E).$$

The optimal equity contract then consists of a mix of stock and options, with:

$$\beta_S^*(x_M) = \left( p_L \left( \frac{K}{(a_H - a_L)} + 0.5km^2 \right) - \frac{k}{q}m^*(p_H - p_L) \right) / (p_H - p_L), \quad (44)$$

$$\beta_O^*(x_H - E) = \frac{(x_M - p_L x_H) \left( \frac{K}{(a_H - a_L)} + 0.5km^2 \right) + \frac{k}{q}m^*(p_H x_H - x_M)}{(p_H - p_L)x_M}. \quad (45)$$

To implement the optimal payments, $w_H > 0$ and $W_L = 0$, defined in (17), the board sets $\beta_S = 0$ and $\beta_O = w_H^*/(x_H - E)$. The optimal equity contract then consists solely of stock options, with:
\[
\beta^*_0 = 0.5 \frac{-km^2 + 2K(a_H - a_L)}{(p_H - qp_Lm^*)(x_H - E)} \text{ and } \beta^*_S = 0.
\]

Proof of Propositions 5 and 7

Case 1 \((k < k_T)\)

When \(k < k_T\), the level of manipulation is determined by (20). Direct computations show that:

\[
dm^* \frac{dk}{dk} = \frac{(p_H - p_L)(1 - a_H)(x_M - p_Lx_H)}{k^2 \left(1 - a_H \right) (p_H - p_L + p_H)} > 0.
\]

(47)

Taking the first derivatives of (19) and (18) and using (20) yields:

\[
dw_H \frac{dk}{dk} = -\frac{(1 - m')kdm^*}{(p_H - p_L)} \frac{(1 - 0.5m^*)m^*}{(p_H - p_L)} < 0,
\]

(48)

\[
dW_L \frac{dk}{dk} = -\frac{(p_H - p_Lm^*)kdm^*}{(p_H - p_L)} \frac{p_H - p_L0.5m^*m^*}{(p_H - p_L)} < 0,
\]

(49)

where \(dm^* \frac{dk}{dk} > 0\). The convexity of the optimal pay plan declines when \(k\) increases. Using (15), we have:

\[
\frac{dQ}{dW_L} \left( w_H \left( W_L, m(W_L, k) \right), W_L \right) = \frac{dw_H \left( W_L, m(W_L) \right), W_L \right) dW_L}{dk} + \frac{\partial Q}{\partial w_H} \left( \frac{\partial w_H}{\partial k} + \frac{\partial w_H}{\partial m} \frac{dm}{dk} \right),
\]

which is negative because:

\[
\frac{dQ}{dW_L} \left( w_H \left( W_L, m(W_L) \right), W_L \right) > 0,
\]

as shown in (27); \(\frac{dm}{dk} < 0\), as shown in (49); \(\frac{\partial Q}{\partial w_H} > 0\), and:

\[
\frac{\partial w_H(k, m)}{\partial k} = -\frac{0.5m^2}{p_H - mp_L}
\]

(using (24)) and \(\frac{\partial m}{\partial w_H} = 0\), as shown in (25).

Next, I show that firm value is increasing in \(k\). Using the Lagrangian of the board’s optimization problem (see (37)), we have:

\[
\frac{dG}{dk} = \lambda(0.5m^2) - \mu m > 0,
\]

where \(\lambda > 0\) and \(\mu < 0\), as determined by (38) and (39).

Consider now the effect of a change in \(k\) on the CEO’s expected compensation, \(V\), and rent, \(U_{CEO}\). Substituting (5) and (19) into (28), the expected cost of compensation can be written as:

\[
V = a_Hk / (a_H - a_L) + \frac{p_L(K)}{a_H(a_H - a_L)} - km \left( p_H(1 - m) + 0.5m(p_L + a_H(p_H - p_L)) \right) \right) / (p_H - p_L).
\]

(50)

Taking the first derivative with respect to \(k\) yields:
\[
\frac{dV}{dk} = \frac{-k \left(p_H(1-m) - m(p_H - p_L)(1-a_H)\right)}{(p_H - p_L)} \frac{dm}{dk} - \frac{m \left(p_H(1-m) + 0.5m(p_H + a_H(p_H - p_L))\right)}{(p_H - p_L)},
\]

which, using (20), can be written as:

\[
\frac{dV}{dk} = -(1 - a_H)(x_M - x_Hp_L) \frac{dm}{dk} - \frac{m \left(p_H(1-m) + 0.5m(p_H + a_H(p_H - p_L))\right)}{(p_H - p_L)} < 0,
\]

with \(\frac{dm}{dk} > 0\). The CEO’s expected rent is given by:

\[
U^{CEO} = V - (1 - a_H)0.5km^2 - K,
\]

which yields:

\[
\frac{dU^{CEO}}{dk} = \frac{dV}{dk} - (1 - a_H)0.5 \left(m^2 + 2km \frac{dm}{dk}\right) < 0,
\]

where \(\frac{dV}{dk} < 0\) and \(\frac{dm}{dk} > 0\) (see (52) and (47)).

Case 2 \((k > k_T)\)

When \(k > k_T\), the equilibrium level of manipulation is determined by (12). Direct computations show that:

\[
\frac{dm^*}{dk} = \frac{1}{k} \left(p_L 0.5m^2 - p_H m^*\right) < 0.
\]

Taking the first derivative of (17) and using (54) yields:

\[
\frac{dw_H}{dk} = -\frac{0.5m^2}{p_H - p_L m^*} < 0.
\]

I show next that firm value is increasing in \(k\). Taking the first derivative of the Lagrangian in (37) yields:

\[
\frac{dG}{dk} = \lambda (0.5m^2) - \mu m.
\]

Recall that the values \(\lambda > 0\) and \(\mu < 0\) are determined by \(\frac{dG}{dw_H} = 0\) and \(\frac{dG}{dm} = 0\). Using (17) and (12), the optimal payment \(w_H\) can be written as \(w_H = mk/p_L\). Using \(w_H = mk/p_L\) and \(W_L = w_L = W_H = 0\), we obtain:

\[
\lambda = \frac{p_L(x_M - p_L x_H)(1 - a_H) + 2km p_L(1 - a_H) + ka_H p_H}{k(p_H - mp_L)} > 0
\]

and:

\[
\mu = -(x_M - p_L x_H + km)(1 - a_H)/k < 0,
\]

implying that \(\frac{dG}{dk} > 0\).

Consider now the effects of a change in \(k\) on the CEO’s expected compensation, \(V\), and rent, \(U^{CEO}\). Substituting (5) into (28), and setting \(W_L = 0\), the expected cost of compensation can be
written as:

\[ V = a_H K / (a_H - a_L) + km^2(1 - 0.5a_H). \]  \(57\)

Taking the first derivative with respect to \( k \) yields:

\[ \frac{dV}{dk} = \left( m^2 + 2km \frac{dm}{dk} \right) (1 - 0.5a_H), \]  \(58\)

which, using (54), can be written as:

\[ \frac{dV}{dk} = \left( -\frac{p_H m^2}{p_H - mp_L} \right) (1 - 0.5a_H). \]  \(59\)

Using (57), the CEO’s expected rent can be expressed as:

\[ U^{CEO} = V - (1 - a_H)0.5m^2 - K = a_H K / (a_H - a_L) + 0.5m^2k - K, \]  \(60\)

which, using (54), yields:

\[ \frac{dU^{CEO}}{dk} = -0.5m^2 \frac{p_H}{p_H - mp_L} < 0. \]
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