Corporate Reform and Governance∗

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Abstract

In light of the publicity accorded recent corporate scandals, numerous proposals have been introduced for reforming corporate governance. This paper provides a theoretical framework through which to evaluate these reforms. Unlike various ad hoc arguments that have been made, this framework recognizes that governance structures arise endogenously in response to the constrained optimization problems faced by the relevant parties. As such, we find that there is reason to be suspicious of reforms with respect to their impact on welfare. Indeed, with some exceptions, we find that proposed reforms will have negative and likely unintended consequences, such as increasing management’s incentives to distort information, increasing managerial compensation, and reducing managers’ willingness to take risks.

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1 Introduction

Corporate governance is again an area of interest. After the scandals at Enron, WorldCom, and other firms, many authors, politicians and even practitioners have called for regulatory changes designed to “improve” governance. Reforms such as Sarbanes-Oxley (SOX), the Cadbury recommendations, and numerous other proposals emphasize the attention that corporate governance has received in the public policy arena. Yet, the issue is in fact a very old one; if Smith (1776) did not write in such an elegant style, some of his Wealth of Nations could have come from a recent issue of Fortune or Business Week.\(^1\) That complaints about corporate governance being “ineffective” have been heard since the beginnings of the corporate form suggest that corporate governance is not easily “fixed.” Rather it might make sense to think of corporate governance as akin to the weather, perennially complained about, but beyond human improvement.

Much of the confusion concerning corporate governance likely arises because discussion of the issues typically, but implicitly, assumes governance is “out of equilibrium.” That is, unlike other economic activity, commentators talk as if the invisible hand has yet to guide governance to an equilibrium point. With such a mind set, “reforms,” which consist of requiring all firms to adopt what seems to be a good idea or has been shown historically to be a trait associated with good-performing firms, can seem a sensible course of action. For example, the SOX reform requires a powerful audit committee on the board, and heightened personal consequences for directors if the firm engages in financial misconduct. Yet, the consequences of firms voluntarily adopting these measures are likely to be quite different from the involuntary imposition of these measures on firms. Just as the labor-market equilibrium is quite different when firms voluntarily raise wages as opposed to when wages rise because of a government-imposed minimum wage, the resulting “improvement” in governance from a regulatory-imposed change could be very different from a voluntarily adopted change.

To evaluate the implications of regulations of governance, one must start with a model of what governance would look like in the absence of regulations and derive the implications of alternative regulatory regimes. To do so, it is important that governance be derived endogenously in the model rather than imposed so that changes in the environment can influence the governance structure. In addition, governance must play a role in the real decisions the firm makes so that we can evaluate the quality of the governance in the market equilibrium imposed by a new regulatory regime.

This paper evaluates governance reforms in a model that has these characteristics. For most of the paper, our model is based on Hermelin and Weisbach (1998) and Hermelin’s (2005) adaptation of Holmstrom’s (1999) career-concerns

\(^1\)The directors of [joint stock] companies, however, being the managers rather of other people’s money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance [as owners] ... Negligence and profusion, therefore, must always prevail, more of less, in the management of the affairs of such a company” (Smith, 1776, p. 700).

model. Later, to examine the impact of governance reforms on project choice, we use a variant of the standard hidden-action principal-agent model.

The paper takes a Coasian (Coase, 1960) perspective, insofar as we view governance arrangements as constrained-optimal contracts within the firm. Given this view, “reforms” are simply restrictions on these contracts imposed by an outside authority. In other words, governance reforms are just a special case of contract regulation. We therefore begin our analysis with a review of the contract theory literature on regulation of contracts. This literature identifies several conditions under which restrictions on contracts can be welfare improving. In the context of governance, however, we are generally skeptical that these conditions are met. A possible exception, though, is that government regulations may improve on private contracting when they impose more severe penalties than private parties can impose on each other.

The paper models a number of potential reforms in the context of their being externally imposed restrictions. While a complete analysis of all reforms that have been proposed, or even all of those enacted in the Sarbanes-Oxley regulations, is beyond the scope of the paper, we model explicitly several reforms as a way of illustrating the more general point.

Sections 3 through 5 lay out the basics of the career-concerns model. This model is intended to capture the impact of regulations in reporting requirements aimed at increasing transparency. In the model, a company chooses the “quality” of the performance measures that directors use to assess the CEO’s ability. The CEO can exert effort at distorting this information.

In our setup, a reform that increases disclosure can be thought of as increasing the minimum acceptable level of reporting quality. We show that the consequence of such a reform will be to actually increase the CEO’s incentives to distort information about the firm. In addition, it will also lead to an increase in the probability that the CEO will be fired and, because of both these consequences, an increase in the CEO’s compensation. Moreover, the combination of these effects can actually be to decrease expected profits. Thus, the model implies that regulations stipulating better disclosure decreases efficiency, despite the fact that the improved information is put to good use in employing better quality CEOs on average.

In Section 6, we consider reforms that raise the cost to the CEO of concealing information about the firm. This version of the model is intended to capture the provision of the Sarbanes-Oxley act that makes the CEO personally liable for accounting misrepresentations. Such reforms will be ambiguous a priori (see Proposition 5).

In Section 7, we turn to the question of distortions that reforms could have on the choice of project selection. It has been alleged that the potential penalties faced by managers under Sarbanes-Oxley is to make them more cautious in their choice of project. We show that these reforms can have that effect.

We conclude in Section 8.
2  A Meta-Analysis

Consider a proposed reform of corporate governance that is to be imposed on firms by the state. Can such a reform be welfare enhancing? The question is, in essence, equivalent to one that has been raised in contract theory: Is there scope for welfare-improving restrictions on private contracts? In the contract theory literature, three cases have been identified in which an affirmative answer can be given: (i) there is asymmetric information between the parties at the time of contracting (Aghion and Hermalin, 1990; Spier, 1992); (ii) the contract between the two parties has an externality on a third party (Aghion and Bolton, 1987); or (iii) the courts can impose a remedy or penalty not available to the parties privately (Hermalin and Katz, 1993, in passing). Moreover, when considering rational actors, Hermalin and Katz effectively establish that these are the only three possible cases in which outside interference in private contracting has the potential to be welfare improving.\(^2\),\(^3\)

To the extent that corporate governance can be modeled as a set of contracts among the relevant actors, Hermalin and Katz’s conclusion suggest that there should be little to no scope for externally imposed reforms to be welfare improving. It is difficult to view the major players as irrational. It is unclear what asymmetries of information exist at the time of contracting.\(^4\) Externalities (e.g., potential exploitation of future shareholders) exist, but it is not obvious how external restrictions on governance of the sort that have been proposed necessarily improve these. It strikes us as possible that the only scope for welfare-improving reforms would be for the state to create or strengthen criminal penalties given that private parties are prohibited from imposing such penalties (e.g., incarceration) on each other. Or, in the same vein, to the extent the state currently restricts civil penalties, the state can permit greater use of civil penalties.

If we take corporate governance to fit the Hermalin and Katz setting—essentially, to be a Coasian world—then economic theory provides a useful roadmap for understanding which types of reforms potentially increase value and which types do not. In particular, reforms that increase penalties on the participants beyond those to which they could privately agree are the only ones that are likely to increase overall value. Of course, there is no guarantee that any particular reform will in fact create value; even those that potentially do so have side effects, and the overall change is the aggregate of these multiple effects. The model below provides a framework for understanding these multiple effects.

\(^2\)Hermalin and Katz’s result depends on the private parties being able to bargain to an efficient solution. For instance, if bargaining is alternating-offer bargaining, then there is no scope for efficiency-enhancing restrictions provided (i) the parties are symmetrically informed ex ante; (ii) there is no externality on a third party; and (iii) the state cannot impose a remedy that the parties cannot implement contractually (see Proposition 4 of Hermalin and Katz).

\(^3\)Hermalin and Katz’s conclusions should be seen as an extension of the ideas in Coase (1960).

\(^4\)While shareholders generally possess less information than management, this asymmetry of information arises post contracting (i.e., once management has already been hired).
3 Model

3.1 Timing

The model has the following timing, which is adapted from Hermalin (2005).5

Stage 1. The board of directors (firm) establishes a level of reporting quality, q (its choice may be constrained by legal restrictions—e.g., sec requirements). The board also hires a CEO from a pool of ex ante identical would-be CEOs. A given CEO’s ability, α, is an independent random draw from a normal distribution with mean 0 and variance 1/τ. Normalizing the mean of the ability distribution to zero is purely for convenience and is without loss of generality.

Stage 2. The CEO takes private actions that affect the board’s perception of how he (the firm) is doing. Assume these actions can be summarized by a uni-dimensional variable, e ∈ R+.6

Stage 3. After the CEO has worked for some point and has taken action, the board acquires a private signal, y, about the CEO’s ability. The signal is distributed normally with a mean equal to α + e and a variance equal to 1/q. Letting the precision, q, of the distribution be the same as the quality of reporting, q, is without loss of generality as we are free to normalize “reporting quality” using whatever metric we wish.7

Stage 4. On the basis of the signal, the board updates its estimate of the CEO’s ability. Based on this posterior estimate, the board may decide to fire the CEO and hire a replacement. A replacement CEO’s ability is a random draw from a normal distribution with mean 0 and variance 1/τ. Hiring a replacement incurs a firing cost of f > 0. This can be seen as the cost of the disruption that occurs if the CEO is fired or the cost of searching for a new CEO or both.

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5Inderst and Mueller (2005) and Singh (2004) are two other recent papers concerned with the CEO’s incentives to distort information. Like us, the former is concerned with the board’s making inferences about the CEO’s ability. Their approach differs insofar as they assume the CEO possesses information not available to the board, which the board needs to induce the CEO to reveal. There is no uncertainty about the CEO’s ability in Singh’s model; he is focused on the board’s obtaining accurate signals about the CEO’s actions.

6Specifically, if a is a vector of activities, we are assuming that there is a function e(a) that maps their collective influence on to the board’s perception of how the firm is doing. If k(a) is the CEO’s disutility from pursuing those activities, then the function k(·), introduced infra, is defined as k(e) = min k(a) subject to e(a) = e.

7Hermalin and Weisbach (1998) and Hermalin (2005) adopt an alternative formulation in which the precision is fixed, but the variable in question (i.e., q) is simply the probability that the board observes the signal. As Hermalin shows, however, the two approaches lead to essentially the same analysis (see his §VI).
Stage 5. Revenues are realized. Revenues are $\alpha + \varepsilon$, where $\mathbb{E}\{\varepsilon\} = \mathbb{E}\{\varepsilon|\alpha\} = 0$ and $\alpha$ is the ability of the CEO in place at this final stage. The random variables $y$ and $\varepsilon$ are independently distributed.

3.2 Preferences and Ability

If the CEO in hired at Stage 1 survives to Stage 5, he receives a control benefit of $b > 0$. If he is dismissed prior to this stage (or not hired at all), then he receives a benefit of 0.

The CEO hired at Stage 1 is also compensated with a wage, $w$. This wage is paid regardless of whether the CEO survives to Stage 5. The wage paid a replacement CEO is assumed to be embedded in $f$, the disruption cost.

A CEO’s ability is fixed throughout his career. We follow Holmstrom (1999) by assuming that the CEO, like the board, knows only the distribution of his ability. We justify this assumption by noting that the uncertainty about a CEO’s ability in a particular job is largely uncertainty about the match between him and the job, which is similarly unknown to both the board and the CEO.

The expected utility of a CEO hired at Stage 1 is

$$w + b \Pr\{\text{not fired}\} - k(e),$$

where $k(\cdot)$ is a strictly convex and twice differentiable function. Assume $k(0) = k'(0) = 0$ and that $k'(e) > 0$ for $e > 0$. To ensure existence of a pure-strategy equilibrium, we maintain the following:

Assumption 1 $\inf_{e \in \mathbb{R}_+} k''(e) > b \tau \exp(-1/2)/\sqrt{2\pi}$.

The initially hired CEO has a reservation utility, $u_R \geq b$. That is, (1) cannot be less than $u_R$. Requiring that $u_R$ not be less than $b$ rules out a negative wage.

We assume that individual directors like higher earnings. Following Hermalin and Weisbach (1998), we assume the preferences of the individual directors can be aggregated in such a way that the board acts as if it is a single risk-neutral decision maker with respect to firm profits. Without further loss of generality, we can, thus, take the board’s utility as equal to firm profits.

8It would not change the analysis—other than to complicate the notation—to add a positive constant to revenues so that the probability of negative revenues was arbitrarily small. Similarly, the analysis would be unaffected if we assumed $\alpha + \varepsilon$ were earnings net of production costs but gross of the CEO’s compensation and governance costs.

9Because the signal $y$ is private, it cannot be the basis of compensation. Because final revenues are not a function of managerial action, there is no reason to tie this compensation to final revenues (i.e., to use an incentive contract). If the CEO were are at all risk averse, it would be strictly better to pay him a flat wage.

10Hermalin (2005) makes a similar assumption to guarantee existence of a pure-strategy equilibrium. Specifically, he takes $k(e) = e^2/2$ and assumes

$$1 > b \frac{q\tau}{q + \tau} \frac{\exp(-1/2)}{\sqrt{2\pi}}$$

(unlike here, in his model $q$ is exogenous).
3.3 Updating Beliefs and Monitoring

As we detail later, in equilibrium the board will correctly infer what level of distortionary effort, \( e \), the CEO has spent. Hence, it can subtract out that inferred level, \( \hat{e} \), from \( y \) to get a pure signal of ability, \( \hat{y} \equiv y - \hat{e} \). Define \( \hat{y} = y - e \). As noted, in equilibrium, \( \hat{y} = \hat{y} \). As a benchmark, we will work with \( \hat{y} \) in this section.

Suppose, for the time being, that the board either observed \( e \) (rather than inferred it) or that \( e \) was constant. After the signal, \( y \), is observed, the players update their beliefs about the CEO’s ability. The posterior estimates of the mean and precision of the distribution of the CEO’s ability are

\[
\mu' = \frac{q\hat{y}}{q + \tau} \quad \text{and} \quad \tau' = \tau + q, \tag{2}
\]

respectively (see, e.g., DeGroot, 1970, p. 167, for a proof). The posterior distribution of ability is also normal.

We assumed that the distribution of the signal \( \hat{y} \) given the CEO’s true ability, \( \alpha \), is normal with mean \( \alpha \) and variance \( 1/q \); hence, the distribution of \( \hat{y} \) given the prior estimate of the CEO’s ability, 0, is normal with mean 0 and variance \( 1/q + 1/\tau \).\(^{11}\) Define

\[
H = \frac{q\tau}{q + \tau}
\]

to be the precision of \( \hat{y} \) given the prior estimate of ability, 0.\(^{12}\)

Observe that the board’s posterior estimate of a CEO’s ability is also expected revenues. After fixing (sinking) the CEO’s wage and any other costs, it is also expected profits.

The alternative to retaining the incumbent CEO at stage 4 is to replace him. The expected revenues from a replacement are, by assumption, zero. The expected profit from a replacement CEO is, therefore, \(-f\) (i.e., expected revenue less disruption costs). Subsequent to obtaining a signal, \( \hat{y} \), the incumbent CEO will, thus, be dismissed if \( \mu' < -f \). Using expression (2), we can restate the dismissal condition as

\[
\hat{y} < -\frac{(q + \tau)f}{q} \equiv Y. \tag{3}
\]

Given this option of dismissal, the firm’s expected value prior to receiving

\(^{11}\)The random variable \( \hat{y} - \mu \), where \( \mu \) is the prior estimate (here 0), is the sum of two independently distributed normal variables \( \hat{y} - \alpha \) and \( \alpha - \mu \); hence, \( \hat{y} - \mu \) is also normally distributed. The means of these two random variables are both zero, so the mean of \( \hat{y} - \mu \) is, thus, \( \mu \). The variance of the two variables are \( 1/q \) and \( 1/\tau \) respectively, so the variance \( \hat{y} - \mu \) and, thus, of \( \hat{y} \) given \( \mu \), is \( 1/q + 1/\tau \).

\(^{12}\)As a convention, functions of many variables, such as \( H \), will be denoted by capital letters.
a signal with precision $p$ is

$$V = \int_{-\infty}^{\infty} \max \left\{ -f, \frac{q \tilde{y}}{q + \tau} \right\} \sqrt{\frac{H}{2\pi}} \exp \left( -\frac{H}{2} \tilde{y}^2 \right) d\tilde{y}$$

$$= \frac{\sqrt{H}}{\tau} \phi(Y \sqrt{H}) - f \Phi(Y \sqrt{H}),$$

where $\phi(\cdot)$ is the density function of a standard normal random variable (i.e., with mean zero and variance one) and $\Phi(\cdot)$ is the corresponding distribution function. The second line follows from the first using the change of variables $z \equiv \tilde{y} \sqrt{H}$. In what follows, it is useful to define

$$Z \equiv Y \sqrt{H} = -\frac{f \tau}{\sqrt{H}}.$$

Note that

$$1 - \Phi(Z) = \Phi(-Z) \quad (4)$$

is the probability that the CEO will be retained after the board observes the signal.

**Lemma 1** *Taking CEO compensation, $w$, as fixed, the firm’s expected value is increasing in the quality of reporting, $q$ (i.e., $\partial V / \partial q > 0$).*

### 4 CEO Choice of Effort

As noted earlier, the board wishes to base its firing decision on $\tilde{y}$; that is, the signal $y$ with the CEO’s efforts subtracted out. To calculate $\tilde{y}$ from $y$, the board needs to know $e$, the CEO’s efforts. Because, however, the board doesn’t observe $e$, it can only subtract out the amount of effort it anticipates the CEO expended, $\hat{e}$ (in a pure-strategy equilibrium, $\hat{e}$ and $e$ will be the same).

Based on its inference, the board bases its firing decision on $\tilde{y} = y - \hat{e}$. It will, therefore, fire the CEO if

$$\tilde{y} < Y; \quad (5)$$

that is, if

$$y - \hat{e} = \tilde{y} + e - \hat{e} < Y, \quad \text{or}$$

$$\tilde{y} < Y + \hat{e} - e. \quad (6)$$

The $Y$ in expressions (5) and (6) is the same as in (3).

Using (4), the CEO’s expected utility as a function of $e$ is

$$b \Phi \left( -\left( Y + \hat{e} - e \right) \sqrt{H} \right) - k(e). \quad (7)$$
The CEO chooses $e$ to maximize (7) given his anticipation of the board’s belief about his effort, $\hat{e}$. The first-order condition is

$$b\phi\left(-\left(Y + \hat{e} - e\right)\sqrt{H} - k'(e)\right) = 0.$$  \hspace{1cm} (8)

In a pure-strategy equilibrium, the board must correctly anticipate the CEO’s effort; that is, $\hat{e} = e$ in equilibrium. The equilibrium value of effort, $e^*$, is, thus, the solution to

$$b\phi\left(-Y\sqrt{H} - k'(e^*)\right) = 0.$$  \hspace{1cm} (9)

Because $k'(\cdot)$ is strictly monotonic, with a range of $[0, \infty)$, a unique $e^*$ exists that solves (9). In other words, if a pure-strategy equilibrium exists, then it is unique and, in it, the CEO supplies effort $e^*$. Because $k'(0) = 0$, $e^* > 0$.

The one remaining step is, thus, to establish that a pure-strategy equilibrium exists:

**Lemma 2** Under Assumption 1, a pure-strategy equilibrium exists and is unique.

Without Assumption 1 it is possible that no pure-strategy equilibrium exists. Fixing the board’s expectation of the CEO’s effort, the CEO’s marginal benefit of trying to influence the board’s beliefs about his ability is increasing in $b$ and $H$. The reason it is increasing in $b$ is obvious. The greater the conditional precision of the signal, $H$, the more weight the board places on the signal, which increases the CEO’s motivation to distort it. In equilibrium, however, the board has to form correct expectations. If the CEO’s incentives to distort the signal are large, then the board will expect the CEO to choose a high level of effort. Because of the cost he bears, at some point it ceases to be worth it to the CEO to “live up” to the board’s expectations if those expectations are too great. In other words, it is possible that, absent Assumption 1, the only candidate pure-strategy equilibrium entails an expected level of effort that is so great that it does not maximize the CEO’s expected utility to meet that expectation.$^{13}$ Assumption 1 effectively sets an upper bound on $bH$ that ensures that board’s expectation won’t be so great as to induce the CEO not to live up to it.

An important issue is what is the effect of an increase in $q$, the quality of reporting, on $e^*$, the equilibrium level of distortionary effort?

**Proposition 1** The CEO’s equilibrium effort at distortion increases with the quality of reporting; that is, $de^*/dq > 0$.

Proposition 1 demonstrates that a potential unintended consequence of higher quality reporting is greater effort by management (the CEO) to distort information about performance.

$^{13}$Although $e = e^*$ is always a local maximum of the CEO’s utility, it ceases to be a global maximum when $bH$ gets too large. See Hermalin (2005) for details.
The CEO’s chance of dismissal is also increasing in $q$. To see this, differentiate (4) with respect to $q$. The derivative is

$$-\phi(-Z) f_\tau \frac{f_\tau}{2 H^{3/2}} \times \frac{\tau^2}{(q + \tau)^2} < 0.$$ 

Hence,

**Proposition 2** The CEO’s equilibrium probability of being fired increases with the quality of reporting.

## 5 Optimal Reporting Quality

The CEO will accept employment in Stage 1 only if his expected utility exceeds his reservation utility; that is, only if

$$w + b\Phi(-Z) - k(e^*(q)) \geq u_R.$$ 

(10)

All else equal, the board prefers that $w$ be as small as possible, which means the CEO’s participation constraint, (10), binds. Substituting that constraint into expected profits net of CEO compensation, the firm’s expected profit (and, thus, the board’s expected utility) is

$$\sqrt{H_\tau} \phi(Z) - f_\tau \Phi(Z) + b\Phi(-Z) - k(e^*(q)) - u_R.$$ 

(11)

There is no reason a priori to expect (11) to be concave in $q$ or to have an interior maximum. For instance, consider the case in which the set of possible reporting qualities, $q$, is $[q, \infty)$, $q > 0$, and $k(e) = e^2/2$. When $bf\tau \geq 1$, we have the following:

**Proposition 3** Suppose the lowest possible level of reporting quality, $q$, is strictly positive and $k(e) = e^2/2$. Then, if $bf\tau \geq 1$, the level of reporting quality that maximizes expected firm profit subject to the CEO’s participation constraint is $q = q^*$.

The parameter $q$ should be seen as the minimum possible quality of reporting. As such, it reflects the bounds imposed on the firm by SEC and other reporting requirements, as well as the fact that some information will be available to directors through press stories and other similar channels.

The intuition behind Proposition 3 is as follows. With a large private benefit, $b$, the CEO’s motivation to invest in distorting behavior is also large. The firm (directors) must, in a sense, compensate the CEO for this investment. In addition, the firm must also compensate the CEO for the risk of losing that

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14 If $k(e) = e^2/2$, then Assumption 1 requires $b < \sqrt{2\pi} \exp(1)/\tau$ (i.e., roughly, $bt < 4.133$).
benefit. Combined, these two effects can be so large that the directors wish to commit as much as possible \textit{ex ante} to keeping the CEO. They do this by choosing to have low-quality reporting, because this translates into the board being less responsive to the signal (\textit{i.e.}, \(y\)) than they it would be if \(y\) were a more precise signal.

Observe that, under the assumptions of Proposition 3, the profit-maximizing quality of reporting is the smallest allowed level, \(q\). That is, the benefits of more accurate information as identified by Lemma 1 can be dominated completely by the adverse consequences discussed above.\(^{15}\) Consequently, if the effect of reforms such as Sarbanes-Oxley is to raise \(q\), then reforms will serve to reduce firms’ profits.

**Corollary 1** Under the assumptions of Proposition 3, if the effect of externally imposed reforms is to raise the minimum permissible quality of reporting information, \(q\), then these reforms will cause (i) a fall in firm profits; (ii) an increase in the CEO turnover rate; and (iii) an increase in CEO compensation.

**Proof:** Follows immediately from Lemma 1 and Propositions 2 and 3.

Proposition 3 and its corollary have clear implications for thinking about reforms that change reporting requirements. While such reforms leader to better information about managerial performance, they can also lead to higher management compensation and more—ultimately wasted—effort at distorting information by management. As such, these results illustrate the point made more generally in Section 2 about the cost of externally imposed restrictions on private contracting.

Point (iii) of the corollary is, in fact, quite general.

**Proposition 4** The CEO’s equilibrium compensation, \(w\), is increasing in the level of reporting quality, \(q\).

The analysis has so far focused on the case when the CEO’s private benefit, \(b\), is relatively large. When it is small, the amount the CEO has at risk and, thus, his incentive to invest in distortionary effort is likewise small. Numerical calculations—see Figure 1—show that expected profit (\textit{i.e.}, expression (11)) can start to rise in \(q\) once \(q\) is large enough. In contrast, for \(b\) large (\textit{i.e.}, under the assumptions of Proposition 3), a graph similar to Figure 1 would show an everywhere decreasing \(\Pi(q)\).

For the situation depicted in Figure 1, the optimal \(q\) depends on the value of \(q\). If, for example, \(q\) corresponds to the line \(\ell_1\) in Figure 1, then \(q\) is optimal. If, however, it corresponds to the line \(\ell_2\), then the largest possible value of \(q\) is optimal.

\(^{15}\)A large literature in accounting emphasizes the usefulness of accounting information for the purpose of improving contracts among parties, including bondholders, managers, and other firms (see Watts and Zimmerman, 1986, especially pages 312–317, for discussion and references). A more compete model, that incorporated these demands for more accurate information, could well lead to a higher optimal value for \(q\). Alternatively, \(q\) could be seen as the lowest value of \(q\) consistent with meeting these other demands.
Figure 1: Plot of expected profit, $\Pi(q)$ (i.e., expression (11)) under the assumptions that $k(e) = e^2/2$, $b = 1$, $f = 1/5$, $\tau = 1$, and $p(q) = q$. Observe the asymptote corresponds to $\lim_{q \to \infty} \Pi(q) \approx .81$. 

Figure 1 suggests the possibility of a tipping dynamic vis-à-vis regulation. For low levels of regulation (e.g., those corresponding to $\ell_1$), the regulations are binding insofar as the firm chooses the lowest quality reporting permitted. However, once the regulations go above a certain point—for instance, the point at which the $\Pi(q)$ curve crosses the asymptote line in Figure 1—the firm would optimal wish to make the quality of reporting as large as possible. For example, in the figure, suppose that a regulation raised the minimum level from $q = .05$ (approximately $\ell_1$) to $q = .3$ (approximately the value that minimizes $\Pi(q)$). The firm would respond by, then, raising $q$ as high as possible.

**Observation 1** The following scenario is possible: At a low enough minimum level of reporting quality, a firm optimally adopts this lowest permitted quality of reporting. At a high enough minimum, however, the firm jumps to requiring the maximum possible level of reporting quality, a level strictly greater than the minimum required.

The intuition behind this insight is as follows. As discussed, in setting $q$ the board is trading off two factors. On the one hand, as shown by Lemma 1, raising $q$ increases firm value ceteris paribus. On the other hand, raising $q$ lowers the CEO’s utility, both because it increases the probability he will be dismissed and because it induces him to expend more effort in distortionary activities. The CEO must be compensated for this loss of utility, which means his wage rises. In the scenario illustrated in Figure 1, initially the marginal cost of increasing $q$ exceeds the marginal benefit. At some point, however, $q$ gets sufficiently large that the value $-Y\sqrt{H}$ is sufficiently far into the right tail of the normal distribution that a further push into the tail increases the CEO’s incentive to distort the signal by only a small amount (see expression (9)) and raises the probability that he is fired by only a small amount, so the overall increase in disutility is small. Consequently, the firm’s marginal cost of increasing $q$ can fall below the firm’s marginal benefit of doing so.

### 6 Raising the Cost of Concealment

One view of reforms, such as Sarbanes-Oxley, is that they raise the cost to management of distorting information by imposing criminal penalties on managers who misreport information. In doing so, SOX falls into the category of reforms that, according to contract theory, could potentially increase welfare. Recall, as noted in Section 2, private contracts cannot impose criminal penalties, which means there is a scope for such reforms to be welfare improving insofar as they represent the creation of a remedy not available privately to the parties in question.

To model the situation we suppose, now, that $q > 0$ is fixed exogenously. What is endogenous is the probability $p$ that the board does not observe the signal, $y$. In this version of the model, $p$, is chosen by the CEO in Stage 2 along with $e$. The cost to the CEO is $c(p, r)$, where $r$ is a parameter (e.g., a reporting
Assumption 2 The cost function $c(\cdot, \cdot)$ satisfies

(i) $c(0, r) = 0$ and $\partial c(0, r)/\partial p = 0$ for all $r$;

(ii) $\partial c(1, r)/\partial p = \infty$ for all $r$;

(iii) $\partial c(p, r)/\partial p \geq 0$ and $\partial^2 c(p, r)/\partial p^2 > 0$ for all $r$; and

(iv) $\partial c(p, r)/\partial r \geq 0$ and $\partial^2 c(p, r)/\partial p \partial r > 0$ for all $r$ and all $p \in (0, 1)$.

In essence, Assumption 2 establishes that the cost function is well behaved and that an increase in $r$ raises both the cost and the marginal of efforts to hide the signal.

The cost $c(p, r)$ can be interpreted in a number of ways. One interpretation is that $r$ is the probability that the CEO’s efforts to hide the signal are detected, in which case his penalty is an increasing function of his efforts to hide the signal, $p$. Another interpretation is that $r$ is the penalty if caught trying to conceal the signal and the probability of being caught is greater the more egregious the efforts to hide the signal. Yet another interpretation is that $r$ is a parameterization of the nuisances, obstacles, or other costs (e.g., signing certificates of having reviewed the financial accounts) associated with hiding the signal and that these costs are greater the more effort is going into hiding the signal.

The CEO’s expected utility is

$$w + b\Pr\{\text{not fired}\} - k(e) - c(p, r) = w + b\left(p + (1 - p)\Phi(-Y + e^* - e)\sqrt{H}\right) - k(e) - c(p, r). \quad (12)$$

Observe that the cross-partial derivative of expression (12) with respect to $e$ and $p$ is negative; that is, effort at concealment, $p$, and effort at distortion, $e$, are substitute activities for the CEO.

Because $1 - p < 1$, Assumption 1 is still sufficient for the CEO to play a pure strategy with respect to his choice of $e$. Moreover, because the CEO’s benefits are linear in $p$ and his costs convex in $p$, he has a unique best response in terms of $p$ as well. From Assumption 2(i) and (ii) that optimal $p$ is in the interval $(0, 1)$. Let $e^*(r)$ and $p^*(r)$ define the CEO’s optimal choices; observe they satisfy the first-order conditions:

$$\left(1 - p^*(r)\right)b\phi\left(-Y\sqrt{H}\right)\sqrt{H} - k'(e^*(r)) = 0; \quad \text{and} \quad (13)$$

$$b\left(1 - \Phi(-Y\sqrt{H})\right) - \frac{\partial c(p^*(r), r)}{\partial p} = 0. \quad (14)$$

From Assumption 2(iv) and (14), it follows that $p^*(r) < 0$. In turn, that result, expression (13), and the convexity of $k(\cdot)$ imply that $e^*(r) > 0$. To summarize:
Lemma 3 An increase in the parameter $r$ results in the CEO expending less effort on hiding the signal (i.e., $p^*(r) < 0$) and more effort on distorting the signal (i.e., $e^*(r) > 0$).

Recall that the CEO’s participation constraint is binding. Consequently, the firm’s expected profit (and, thus, the board’s expected utility) is

$$
(1-p^*(r)) \left( \frac{\sqrt{H}}{\tau} \phi(Z) - f\Phi(Z) \right) \\
+ b(p^*(r) + [1 - p^*(r)]\Phi(-Z)) - k(e^*(r)) - c(p^*(r), r) - u_R .
$$

Similar to expression (11) earlier, there is no reason to expect ex ante that expression (15) is concave in $r$ or admits an interior solution. In fact, depending on the functional forms and the parameter values it is possible that the optimal $r$ is the smallest possible $r$, the largest possible $r$, or potentially some level in the middle. For example it can be shown that if

$$k(e) = e^2/2 \quad \text{and} \quad c(p, r) = -r \times \left( \ln(1 - p) + p \right)$$

(note $c(p, r) \geq 0$ and satisfies Assumption 2), then

- the optimal $r = 0$ if $q = 4/10$, $\tau = 1$, $f = 1/5$, and $b = 1$; but
- the optimal $r \to \infty$ if $q = 4/10$, $\tau = 1$, $f = 1/5$, and $b = 1/3$.

The fact that the optimal $r$ could be infinite means, in theory, increasing the limit on penalties for concealing information could be welfare improving. In other words, if there is some $\tau$ such that $r \leq \tau$ and that constraint is binding because of limits on penalties, then strengthening penalties is welfare improving. On the other hand, the fact that the optimal $r$ could be zero means, in theory, that mandating increased penalties could be welfare reducing. In other words, if there is some $\tau$ such that $r \geq \tau$ and that constraint is binding because of mandatory minimum penalties, then further increasing penalties is welfare reducing. To summarize

**Proposition 5** When the CEO can take efforts to conceal the signal, then increasing the limit on penalties can, but won’t necessarily, increase welfare. Furthermore, raising the mandatory penalties can, but won’t necessarily, reduce welfare.

In other words, Proposition 5 indicates that there is no obvious social policy with respect to the penalties imposed externally on CEOs who seek to conceal information.
7 Project Selection

One effect that Sarbanes-Oxley is alleged to have is that it has caused CEOs to be more cautious in their selection of new projects.\footnote{In this paper, we focus on the CEO’s selection of projects. Another perspective is that SOX has made boards more reluctant to pursue risky strategies because of directors’ increased personal liability. This perspective is, however, complementary to the one pursued here insofar as an essentially identical analysis would ensue if we modeled the board as the agent of the shareholders (as compared to here where we are modeling the CEO as the agent of the board).} This view has, for example, been expressed to us by the CEO of a major software firm (private communication). It is also hypothesized to exist by Cohen et al. (2004), who also find empirical evidence that there has been a drop in R&D and capital expenditures post passage of SOX.\footnote{Cohen et al.’s argument for why SOX could cause more caution is different than ours. They argue that SOX has made CEOs more liable for their subordinates’ activities while not improving their control over them. Hence, CEOs will tend to avoid operations that they have less control over. New projects and expansion are taken to represent such operations. In contrast, our model in this section assumes that SOX raises the cost of failure to the CEO regardless of the actions of his CEO. Were the Cohen et al. argument formalized, their model might be one in which the CEO had to select both project complexity and supervisory effort, with SOX’s raising the cost of that effort. As will become clear, that is different than the approach taken here.} In this section, we explore how changes in reporting quality and transparency could affect project choice.

The analysis of project choice is inherently an analysis of a hidden-action model. While there is a hidden-action component to the model presented above, it does not represent a useful hidden-action model for the perspective of studying project choice. This is because, in our earlier model, the board did not care about the CEO’s choice of effort \textit{per se}. Moreover, the board had no ability to affect the CEO’s choice of effort contractually: The signal $y$, the only evidence of the CEO’s choice of effort, is a private signal and, therefore, cannot be the basis of a contract. Even if $y$ were verifiable, problems would arise: Recall that the board would like $e$ to be low in order to reduce the equilibrium level of compensation. But an incentive contract that encourages a low level of effort means paying the CEO according to a schedule in which better performance (\textit{i.e.}, higher $y$) is penalized relative to worse performance (\textit{i.e.}, lower $y$). Such a scheme seems unrealistic, to say the least.

Because our previous model is ill-suited to studying the question of project choice, we employ a straightforward variant of the standard hidden-action principal-agent model. Specifically, assume the following timing:

1. The board hires the CEO by offering him a contract on a take-it-or-leave-it basis. The CEO accepts provided his equilibrium expected utility under that contract exceeds his reservation utility, $u_R$. For convenience, we normalize $u_R = 0$.

2. On the equilibrium path, the CEO will accept the contract. He chooses the innovativeness, $x$, of a project to undertake. Assume $x \in [0, 1]$. Project innovativeness can be seen as the weight, $x$, placed on innovative tech-
nologies, methods, and strategies versus the weight, $1-x$, placed on well-established technologies, methods, and strategies.

3. The project has three possible outcomes: failure, state 0; moderate success, state 1; and overwhelming success, state 2. Let $P_i(x)$ denote the probability of state $i$’s arising given complexity $x$:

$$P_i(x) = \begin{cases} 
  x\rho_2, & \text{if } i = 2 \\
  x\rho_1 + 1 - x, & \text{if } i = 1 \\
  x\rho_0, & \text{if } i = 0
\end{cases} \quad (16)$$

where $\rho_i > 0$ all $i$ and $\sum_i \rho_i = 1$. The functions $P_i(\cdot)$ are common knowledge. That higher $x$ raises both the probability of overwhelming success and the probability of failure is consistent with the idea of $x$ parameterizing project risk.

4. Payments and profits are realized. As before, assume that the directors are risk-neutral maximizers of firm value. The firm’s—and, thus, the directors’—payoff is $\xi_i - w_i$, where $\xi_i$ is the project’s gross payoff in state $i$, and $w_i$ is the CEO’s compensation in state $i$.

We assume that the CEO is risk averse. Specifically, his utility is $U(w) - K(x)$, where $U(\cdot)$ is a twice-differentiable, strictly increasing, and strictly concave function. The function $K(\cdot)$ is twice differentiable, strictly increasing, and convex. Assume $K(0) = 0$. Observe the monotonicity of $U(\cdot)$ implies the existence of an inverse function $U^{-1}(\cdot)$. For convenience, we assume the domain of $U^{-1}(\cdot)$ is $\mathbb{R}$; that is, for any $u \in \mathbb{R}$ there exists a $w$ such that $U(w) = u$. The function $K(\cdot)$ is assumed to be increasing because we assume that greater innovation is harder to manage and, thus, raises the disutility suffered by the CEO. A critical assumption is the following:

$$\max_{x \in (0,1]} \sum_{i=0}^{2} P_i(x)\xi_i - U^{-1}(K(x)) > \xi_1 - U^{-1}(0) \quad (17)$$

Without assumption (17), even in a first-best world the optimal decision would be to avoid risky (innovative) projects.

One can view the consequences of reforms such as Sarbanes-Oxley in the following way. It seems reasonable to postulate that a CEO will only run afoul of such reforms in the case of poor performance. In terms of this section’s model, this could be captured by assuming that the CEO loses $g$ utility in the case of project failure; that is, his net utility should the project fail is $U(w_0) - g$. We can think of $g$ in a number of ways: the expected penalty should the project fail (including, for instance, the costs of defending oneself against prosecution and litigation); the expected cost of dealing with the hassles associated with failure under these reforms; or some combination thereof.
To solve for the optimal contract, observe that if the directors wish to implement $\hat{x}$, then the optimal contract solves
\[ \min_{\{w_0, w_1, w_{\hat{x}}\}} \sum_{i=0}^{2} P_i(\hat{x})w_i \] (18)
subject to
\[ \rho_2 U(w_2) - (1 - \rho_1)U(w_1) + \rho_0 (U(w_0) - g) - K'(\hat{x}) = 0 \] (IC)
\[ \sum_{i=0}^{2} P_i(\hat{x})U(w_i) - g\hat{x}\rho_0 - K(\hat{x}) \geq 0. \] (IR)

As is well known (see, e.g., Grossman and Hart, 1983), the IR constraint is binding.\textsuperscript{18}

It is readily seen that the two constraints imply:
\[ W_1(\hat{x}) = U^{-1}(K(\hat{x}) - \hat{x}K'(\hat{x})). \] (19)

Observe that
\[ W'(x) = -\frac{1}{U'(U^{-1}(x))} xK''(x) < 0. \]

The more innovative is the project the directors wish the CEO to pursue, the less they reward him for moderate success.

Considering IC, we have
\[ \rho_2 U(w_2) - (1 - \rho_1)(K(\hat{x}) - \hat{x}K'(\hat{x})) + \rho_0 (U(w_0) - g) - K'(\hat{x}) = 0. \]

Hence,
\[ w_2 = U^{-1}\left(\frac{(1 - \rho_1)K(\hat{x}) + (1 - (1 - \rho_1)\hat{x})K'(\hat{x}) - \rho_0 (U(w_0) - g)}{\rho_2}\right) \equiv U^{-1}(u_2). \]

The directors’ minimization program (18), therefore, reduces to
\[ \min_{w_0} \rho_0 w_0 + \rho_2 U^{-1}(u_2). \]

The first-order condition is
\[ \rho_0 + \rho_2 \frac{1}{U'(U^{-1}(u_2))} \frac{\partial u_2}{\partial w_0} = \rho_0 - \rho_2 \frac{1}{U'(U^{-1}(u_2))} \rho_0 U'(w_0) = 0. \]

Observe this last equality implies
\[ U'(w_0) = U'(U^{-1}(u_2)) = U'(w_2). \] (20)

\textsuperscript{18}Implicitly, we are assuming that the CEO’s choice of $x$ to maximize his expected utility does not have a corner solution. It is straightforward to impose restrictions on $K(x)$ to rule out corner solutions.

The function $U'(\cdot)$ is strictly monotonic, so (20) implies $W_0(\hat{x}) = W_2(\hat{x})$; that is, the CEO is paid the same amount both when the project is overwhelmingly successful and when it fails! We will return to this, arguably unrealistic, result below.

We can rearrange (20) to yield

$$
\rho_2 U(w_0) = (\rho_0 + \rho_2) K(\hat{x}) + (1 - (\rho_0 + \rho_2)\hat{x}) K'(\hat{x}) - \rho_0(U(w_0) - g).
$$

Solving for $U(w_0)$, we find

$$
W_2(\hat{x}) = W_0(\hat{x}) = U^{-1}\left(K(\hat{x}) - \hat{x}K'(\hat{x}) + \frac{K'(\hat{x}) + \rho_0 g}{\rho_0 + \rho_2}\right). \tag{21}
$$

Direct differentiation of (21) reveals

$$
\text{sign } W'_2(x) = \text{sign } W'_0(x) = \text{sign } \left(\frac{1}{\rho_0 + \rho_2} - x\right) > 0.
$$

In other words, the more complex the project the directors wish the CEO to pursue, the more they reward him for overwhelming success and for failure.

The following lemma follows immediately from expressions (19) and (21).

**Lemma 4** Holding fixed the level of project complexity desired by the board, $\hat{x}$, an increase in the adverse regulatory consequence for failure, $g$ (e.g., introduction of SOX) raises the compensation paid CEOs both for overwhelming success and for failure, but leaves unchanged their compensation for moderate success.

Define

$$
C(x) = \sum_{i=0}^2 P_i(x)W_i(x). \tag{22}
$$

In other words, $C(\cdot)$ is the firm’s cost schedule for implementing various levels of project complexity. The directors choose $x$—and hence offer the CEO $(W_0(x), W_1(x), W_2(x))$—to solve

$$
\max_x \sum_{i=0}^2 P_i(x)\xi_i - C(x). \tag{23}
$$

**Proposition 6** The complexity of projects implemented in equilibrium (i.e., $x$) either remains constant or falls as a consequence of an increase in the impact of reforms (i.e., an increase in $g$). If the choice of complexity problem (23) has an interior solution, then an increase in the impact of reforms strictly reduces the level of the project implemented in equilibrium.

---

By an interior solution we mean that the first derivative is zero at the optimal $x$ and the local second-order condition is met.
As is well known (see e.g., Grossman and Hart, 1983; Hermalin, 1994), the principal’s optimization problem is not necessarily globally concave even if the underlying functions (e.g., $K(\cdot)$) have the appropriate concavity or convexity (see Hermalin, 1994, for examples). As a consequence, the second-best effort level (i.e., $x$) does not necessarily vary continuously or even strictly monotonically in response to changes in exogenous variables (e.g., $g$). Consequently, while we know that an increase in $g$ cannot increase $x$ in this model, we don’t know that it necessarily reduces it. Moreover, if it does reduce it, we don’t know that the change is continuous in $g$.

While this model agrees with the perceived wisdom vis-à-vis sox’s leading to the selection of less risky projects, the model has, as noted earlier, a curious feature insofar as the CEO’s compensation is non-monotonic in performance: $W_2(x) = W_0(x) > W_1(x)$. Although there is nothing new in the possibility of a principal-agent model’s yielding a non-monotonic payment schedule (see, e.g., Grossman and Hart, 1983), a non-monotonic schedule is typically seen as an undesirable result (see Grossman and Hart, 1983, for a discussion). Despite taking that concern seriously—see below—it might be worth first defending non-monotonicity in this particular instance: A possible interpretation of $W_0(x)$ is that it is a golden parachute. Payments under a golden parachute often exceed a CEO’s typical annual compensation. Typical compensation can be seen as the equivalent of $W_1(x)$ in this model.

On the other hand, non-monotonic compensation is generally not the norm. It is worth, therefore, considering the model with a monotonicity constraint:

$$w_2 \geq w_1 \geq w_0.$$ (MW)

For a desired $\hat{x}$, the directors’ problem is (18) subject to IC, IR, and MW. The last constraint must bind, given that optimization without that constraint leads, as we saw, to its violation. Moreover, the binding condition is that $w_1 \geq w_0$.

Define $\tilde{C}(\cdot)$ with respect to $(\tilde{W}_0(x), \tilde{W}_1(x), \tilde{W}_2(x))$ in a manner analogous with the definition of $C(\cdot)$. The directors’ problem is to offer the contract consistent with maximizing (23), except now $C(x)$ is replaced with $\tilde{C}(x)$.

Even with these changes, the impact of reforms on project choice remains the same:

**Proposition 7** Assume that compensation must be monotonic. The complexity of projects implemented in equilibrium (i.e., $x$) either remains constant or falls as a consequence of an increase in the impact of reforms (i.e., an increase in
g). If the choice of complexity problem (23) has an interior solution, then an increase in the impact of reforms strictly reduces the level of the project implemented in equilibrium.

Propositions 6 and 7 illustrate that, consistent with the “popular” view, the passage of SOX should lead to less risk taking with respect to project choice. Finally, because $g$ is lost to the the board-ceo “partnership,” its increase must reduce joint surplus. Moreover, because the CEO is being held to his reservation utility, this surplus loss is suffered entirely by the firm.

8 Conclusion

In response to the spate of recent corporate scandals, countries have passed a number of “reforms” aimed at improving corporate governance. Economics, despite a long history of studying regulation, has been slow, in the case of governance reforms, to provide a conceptual framework for their evaluation. Such a framework requires treating governance institutions as endogenous, so that we can evaluate behavioral changes in response to a new governance restriction. This paper provides models of endogenous governance and studies some commonly discussed reforms such as those in the Sarbanes-Oxley Act.

Our model is an extension of the Holmstrom (1999) career-concerns model. In our model, a CEO is evaluated by his board and receives a wage and private benefits from the job. The board receives a signal about the CEO’s performance, and will replace the CEO if, by its best estimate, a replacement CEO is expected to yield greater profits than the current one (once transition costs are accounted for). The CEO can exert effort to distort the signal the board receives and has incentives to do so because of the private benefits associated with the job. We assume that the board can specify ex ante how informative a signal the board will receive and the informativeness of the signal is assumed to be known at the time the CEO agrees to a contract.

In this model, we first evaluated a reform that increases the minimum precision of the signal (minimum quality of reporting). In equilibrium, this increase leads to higher turnover of CEOs, and greater compensation for CEOs. The increase in compensation can outweigh the benefit of better information about the CEO, so that a firm’s profits fall in response to a reform that increases the minimum quality of reporting.

We next considered a model in which the government can increase the (expected) costs borne by the CEO when he distorts the information the board receives (e.g., making executives personally liable for the firm’s misstatements). This type of reform can increase value if the extra cost is sufficiently large to deter the CEO from distorting the information. Observe that for this reform to be welfare improving, the increased cost must represent a punishment unavailable to the parties privately (e.g., incarceration).

20 By an interior solution we mean that the first derivative is zero at the optimal $x$ and the local second-order condition is met.
Finally we evaluated a hidden-action model that allowed us to assess the effect on risk-taking of reforms that potentially impose penalties for bad outcomes. We do so to evaluate the argument that reducing risk-taking is a potential deleterious effect of governance reforms such as SOX. Our model bears out this intuition; incentives to take risks are reduced when managers face penalties for bad outcomes. While this might, at first, seem obvious; one needs to remember that the board could “undo” the negative incentives of the penalties by adjusting the rest of the CEO’s compensation package. Hence, it is necessary to show that the board chooses not to do so.

For many years, people have tried to make the case that something is “wrong” with corporate governance and we should “reform” it. This view ignores the reality that the observed system of governance has been around for a long time and appears to be the market solution. Many proposed governance reforms, such as increased disclosure, or requirements about the composition of the board or CEO salaries, could have been chosen by the market but in fact were not. Models of endogenous governance provide a start to understanding the reasons why the market might not have picked a contracting arrangement that, on its face, seems appealing. This paper provides a first step in this type of analysis; we expect that, in the future, more such work will greatly improve our understanding of governance reform.
Appendix: Proofs

Proof of Lemma 1: Observe
\[ \frac{d}{dZ} \left( \frac{\sqrt{H}}{\tau} \phi(Z) - f\phi(Z) \right) = -Z \frac{\sqrt{H}}{\tau} \phi(Z) - f\phi(Z) \]
\[ = \frac{f\tau\sqrt{H}}{\tau\sqrt{H}} - f \phi(Z) = 0. \]
Hence,
\[ \frac{\partial V}{\partial q} = \frac{1}{2\tau \sqrt{H}} \phi(Z) \frac{\partial H}{\partial q} \]
\[ = \frac{1}{2\tau \sqrt{H}} \phi(Z) \frac{\tau^2}{(q + \tau)^2} > 0, \] (26)
where the second fraction in the last line is $\partial H/\partial q > 0$.

Proof of Lemma 2: It was established in the text that if a pure-strategy equilibrium exists, then it is unique.

By construction $e = e^*$ solves the first-order condition for the CEO's problem of maximizing his expected utility when the board anticipates he will choose effort $e^*$; that is, $e = e^*$ is a solution to
\[ b\phi((e - e^* - Y)\sqrt{H})\sqrt{H} - k'(e) = 0. \] (27)
If the CEO's objective function, expression (7), is globally concave in $e$ when $e = e^*$, then expression (27) is sufficient as well as necessary; moreover, it defines a global maximum. This means that $e = e^*$ is the CEO's unique best response to the board's anticipating his effort will be $e^*$; that is, that a pure-strategy equilibrium exists.

To establish the concavity of the objective function, we need to show the derivative of (27) is negative. Define
\[ S(e) = (e - e^* - Y)\sqrt{H}. \]
The derivative of (27) is
\[ -b\phi(S(e))S(e)S'(e)\sqrt{H} - k''(e) = -b\phi(S(e))S(e)H - k''(e) \]
\[ \leq -b\phi(S(e))S(e)H - \inf_{e \in \mathbb{R}^+} k''(e) \]
\[ \leq b\phi(1)H - \inf_{e \in \mathbb{R}^+} k''(e) \] (29)
\[ \leq b\phi(1)(e - e^* - Y)\sqrt{H} - \inf_{e \in \mathbb{R}^+} k''(e) \] (30)
\[ < 0, \] (31)
(28) follows because $S'(e) = \sqrt{H}$;

(29) follows because the solution to the problem $\max_{s \in \mathbb{R}} -s\phi(s)$ is $s = -1$ (the first-order condition is $-\phi(s) + s^2\phi(s) = 0$, which has two solutions $s = 1$ and $s = -1$; but only the second satisfies the second-order condition);

(30) follows because $\partial H/\partial q = \tau^2/(p + \tau)^2 > 0$; hence, $H$ is maximized by letting $q \to \infty$; but $\lim_{q \to \infty} H = \tau$; and

(31) follows from Assumption 1 because $\phi(1) = \exp(-1/2)/\sqrt{2\pi}$.

**Proof of Proposition 1:** Given that $k'(\cdot)$ is monotonic, it follows from expression (9) that $de^*/dq$ will have the same sign as $d(\phi(-Y\sqrt{H})\sqrt{H})/dq$. We have

\[
\frac{d\phi(-Y\sqrt{H})\sqrt{H}}{dq} = \phi(-Y\sqrt{H}) \frac{\partial H}{\partial q} + YH\phi(-Y\sqrt{H}) \frac{-f\tau}{2\sqrt{H}^3/2} \frac{\partial H}{\partial q}
\]

\[
\propto 1 - Y f\tau
\]

\[
= 1 + \frac{f^2\tau^2}{\sqrt{H}} > 0
\]

**Proof of Proposition 3:** Let $\Pi$ equal the expression in (11). Straightforward calculations reveal that, when $k(e) = e^2/2$, the sign of $d\Pi/dq$ is the opposite of the sign of the expression

\[
b^2\tau \sqrt{H} \left( q + f^2q\tau + f^2\tau^2 \right) + \frac{1}{\phi(Z)} \left( bf\tau^2 + q(bf\tau - 1) \right).
\]

That expression is positive for all $q$ if $bf\tau \geq 1$. It follows, therefore, that $\Pi$ is maximized by setting $q$ equal to the minimum possible $q$, $q^\prime$.

**Proof of Proposition 4:** As established in the text, the CEO’s equilibrium wage is

\[-b\Phi(-Z) + k(e^*(q)) + u_R.
\]

Differentiating with respect to $q$ yields

\[b\phi(-Z)\frac{\partial Z}{\partial q} + k'(e^*(q))e^*(q)\].

$e^*(q) > 0$ by Proposition 1 and $\partial Z/\partial q > 0$ by (26) and connected discussion. Hence, the last expression is positive as was to be shown.
Proof of Proposition 6: The first part follows from the normal monotonic comparative statics (Milgrom and Roberts, 1990) if we can show that the cross-partial derivative of the expression to be maximized in (23) with respect to \( x \) and \( g \) is negative. This is equivalent to showing that the cross-partial derivative of \( C \) is positive:

\[
\frac{\partial^2 C}{\partial x \partial g} = \rho_0 h'(x) \left( K'(x) - xK'(x) + \frac{K'(x) + \rho_0 g}{\rho_0 + \rho_2} \right) \\
+ \rho_0 x h''(x) \left( K'(x) - xK'(x) + \frac{K'(x) + \rho_0 g}{\rho_0 + \rho_2} \right) K''(x) \left( \frac{1}{\rho_0 + \rho_2} - x \right) > 0, \tag{32}
\]

where \( h(\cdot) \equiv U^{-1}(\cdot) \) and the sign follows because \( U^{-1}(\cdot) \) and \( K(\cdot) \) are convex. Edlin and Shannon (1998) show that if the \( x \) that maximizes (23) is an interior solution, then the comparative statics are strict from (32).

Proof of Proposition 7: The proof follows the same logic as the proof of Proposition 6 provided we show the cross-partial of \( \tilde{C} \) with respect to \( x \) and \( g \) is positive. Observe

\[
\frac{\partial^2 \tilde{C}}{\partial x \partial g} = \rho_0 h'(x) \left( K'(x) - xK'(x) + \frac{K'(x) + \rho_0 g}{\rho_2} \right) \\
+ \rho_0 x h''(x) \left( K'(x) - xK'(x) + \frac{K'(x) + \rho_0 g}{\rho_2} \right) K''(x) \left( \frac{1}{\rho_2} - x \right) > 0,
\]

where \( h(\cdot) \) is as in the proof of Proposition 6.

References


