Information Disclosure and Corporate Governance*

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Abstract

In public-policy discussions about corporate disclosure, more is typically judged to be better than less. In particular, better disclosure is seen as a way to reduce the agency problems that plague firms. We show that this view is incomplete. In particular, our theoretical analysis shows that increased disclosure is a two-edged sword: More information permits principals to make better decisions; but it can, itself, generate additional agency problems and consequent costs to shareholders. Disclosure imposes risks on managers that they seek to ameliorate by distorting their actions in ways that are harmful to shareholders. Because the direct benefits of better disclosure accrue to the shareholders, while the direct costs accrue to management, greater disclosure will also lead to greater executive compensation, regardless of how bargaining power is divided between shareholders and management.

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A response to recent corporate governance scandals, such as Enron and Worldcom, has been the imposition of tougher disclosure requirements. For example, Sarbanes-Oxley (SOX) requires more and better information: More, for instance, by requiring reporting of off-balance sheet financing and special purpose entities; better, by its increasing the penalties for misreporting. In the public's (and regulators') view, improved disclosure is good.

This view is an old one, dating at least from Ripley (1927), and Berle and Means (1932). Indeed, there are good reasons why disclosure can increase the value of a firm. For instance, reducing the asymmetry of information between those inside the firm and those outside can facilitate a firm's ability to issue securities and consequently lower its cost of capital.[1] Fear of trading against those with privileged information could reduce willingness to trade the firm's securities, thereby reducing liquidity and raising the firm's cost of capital. Better disclosure presumably also reduces the incidences of outright fraud and theft by insiders.

But if disclosure is unambiguously value-increasing, why have calls for more disclosure—whether reforms advocated long ago by Ripley or Berle and Means or embodied in more recent legislation like SOX—been resisted by corporations? What is the downside to more disclosure?[2] The direct accounting costs of disclosure could lie behind some of this resistance. Some commentators have also noted the possibility that disclosure could be harmful insofar as it could advantage product-market rivals by providing them valuable information.[3] Although these factors are likely to play some role in explaining corporate resistance to disclosure, it seems unlikely that they are the complete story. In addition to direct costs and costs from providing information to rivals, we argue here that there are important ways in which disclosure affects firms through the governance channel.

In this paper, we view disclosure as a two-edged sword with respect to

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[1]Diamond and Verrecchia (1991) were the first to formalize this idea. For empirical evidence, see Leuz and Verrecchia (2000), who document that firms' cost of capital decreases when they *voluntarily* increase disclosure. The idea that asymmetric information can harm trade dates back to at least Akerlof's (1970) "lemons" model.

[2]Because, as we discuss later, information improves—in a way we make precise—with either the quantity or quality of information, we can think of more or better disclosure as equivalent notions for our purposes.

[3]See Leuz and Wysocki (2006) for a recent survey of the disclosure literature. Feltham et al. (1992), Hayes and Lundholm (1996), and Wagenhofer (1990) provide discussions of the impact of information disclosure on product-market competition.

agency problems. From a contracting perspective, increased information about the firm improves the ability of shareholders and boards to monitor management. However, this improved monitoring does not come for free; managers do not like to be monitored so the increases in monitoring lead to higher equilibrium management compensation. In addition, more informative signals about management's ability provide increased incentives to distort the process of information transmission, either through accounting manipulation, or through myopic real investments that boost short-term profits at the expense of long-term ones.[4]

We formalize this argument by extending the basic career-concerns model (*e.g.,* Holmstrom, 1999) to allow for endogenous decisions about how or what information is disclosed.[5] This is an important extension insofar as it permits an analysis of disclosure policy and the comparative statics associated with it. Section I lays out a basic model, in which the principal (here, called the owners) chooses the precision of the information that it will later receive and on which it bases a decision. As will be shown, the more precise the information will be, the lower will be the agent's (here, called the CEO) expected utility. The harm to the CEO and benefit to the shareholders means that the CEO's compensation increases with the amount or quality of the information disclosed. This result holds regardless of how the bargaining power is distributed between the two in their negotiations over pay. The principal, therefore, trades off the direct benefit of better information versus the additional expense of increased CEO compensation. In equilibrium, this tradeoff implies that the optimal disclosure policy does not maximize the precision of the information released. An implication of this logic is that both CEO salaries and turnover should increase following increases in the quantity of information disclosed about a firm and its managers. Consistent with this argument is the fact that CEO salaries and CEO turnover rates both rose substantially starting in the 1990s (see Kaplan and Minton, 2008).

Anticipating the uses that may be made of information, the CEO has

[4]Consistent with this argument, several studies have documented that passage of the Sarbanes-Oxley Act has lead to a reduction in risk-taking by firms (see Bargeron et al., 2007 and Litvak, 2007). The existence of myopia in corporate investing seems evident from many corporate practices; for example, in a survey of 401 financial executives, Graham et al. (2005) find that over half state that they are willing to delay starting a new project even if it entails a decrease in value in order to meet an earnings target.

[5]Table I summarizes the assumptions of the basic model and the variants discussed below.

incentives to take actions that either directly affect its value or reduce its informativeness. These disruptive actions, which are a consequence of greater disclosure, can be a source of additional agency problems. In Section II, we present a version of the model in which the CEO can take an action that distorts the owners' information. In particular, the CEO's action raises the signal perceived by outsiders. If we think of signal distortion as some kind of accounting manipulation, then the model implies that requiring more accurate information to be released (a higher signal precision in the context of the model) should lead to more manipulation (more distortion).

A particular interpretation of the distortion model is one in which the CEO engages in myopic behavior to boost his short-term numbers at the expense of more valuable longer-term investments. Specifically, building on the model of Stein (1989), we show that the amount of such myopic behavior increases monotonically in the precision of the signal. A very noisy signal provides little information about the CEO's ability to anyone evaluating the CEO, so there is little value to the CEO in trying to boost the signal at the cost of future profits. However, if the signal is informative about his ability, then it makes sense for him to do all that is possible to increase the signal, even if it involves significant reductions in the firm's future profits. In the language of practitioners, increased disclosure provides additional incentives for CEOs to manage "quarter to quarter," even if there are real costs to be borne in the future to make today's profits look higher.

Beyond the question of how precise information reporting should be, a related question concerns the *kind* of information that should be revealed? In particular, should firms reveal information about the manager's actions? Or is it better to simply report their outcomes? To consider this issue, we present a version of the model in which owners decide whether the CEO's actions (*e.g.,* choice of project, strategy, etc.) should be public or not. The key insight in this variant of the model is that the *ex ante* distribution of the action's cash flows will affect the future evaluation of the CEO who undertakes it. Specifically, if his actions are visible, a CEO will have incentives to pursue actions that generate relatively high-variance cash flows, because the outcomes from such actions will count for little when people update their estimates of his ability. Because the CEO is risk averse, he prefers more weight be put on the non-stochastic prior *ceteris paribus*. In other words, with more transparent actions, the CEO is biased toward high-risk actions at the expense of their expected return. Absent transparency, the CEO does not face this distortion. Now, however, although risk still matters to him, he has a greater incentive to maximize the expected return from his actions. It follows that the owners can be better off when action choice is hidden than when it is fully revealed. This effect is reinforced when the CEO can be given an incentive contract based on profits—a cost of such a contract is the need to compensate the CEO for making him bear risk and the risk he bears in equilibrium is greater when his actions are visible than when they are invisible.

In Section IV, we discuss some of the possible shortcomings of our model. Two in particular warrant attention upfront: (i) if it is the *public* release of information that is harmful to the CEO, perhaps the owners (or the board of directors, more realistically) should keep information within the firm, but make sure they are using internally the highest precision information possible; and (ii) if it is the risk that the release of information represents for the CEO that is the source of the problem, then the owners could simply insure the CEO against this risk. Both could, in some contexts, be reasonable points. On the other hand, as we discuss in Section IV, it is not necessarily the publicness of information that adversely affects the CEO: The actions the principals take in response to their private information will often be a public signal of that information (*e.g.,* dismissal of the CEO is a public event). In addition, in many contexts, it really is the shareholders who are making decisions about their agents (*e.g.,* reelect the board, tender shares in a takeover, etc.) and it is not reasonable to assume information would remain private with widely dispersed ownership. With regard to point (ii), it is true that we sometimes see *partial* insurance for the CEO (*e.g.,* golden parachutes as insurance against dismissal), but for moral hazard reasons it is highly unlikely that the owners would wish to *fully* insure the CEO: Full insurance means the CEO's compensation gets bigger the worse he does. The obvious perverse incentives that would create clearly rule it out as a realistic solution. Moreover, as we discuss, there could be other reasons that such contingent contracts are infeasible, for example having to do with the difficulties of actually contracting on the information (the information could, for instance, be difficult to describe *ex ante*, making contracting difficult).

In Section V we discuss some of the implications of our model. In particular, the model predicts that an exogenously imposed increase in information available about the firms should lead to an increase in executive compensation and turnover, as well as an increases in accounting manipulation and distortions of real investments.

Section VI contains a summary and conclusion. Proofs not given in the text can be found in the appendix.

Our paper is related to some other recent work concerning the CEO's ability to distort information and disclosure policy. Like us, Inderst and Mueller (2006) are concerned with inferences about the CEO's ability. Inderst and Mueller's approach differs insofar as they assume the CEO possesses information not available to others. Hence, there is a need to induce the CEO to reveal his information. In a similar spirit, Song and Thakor (2006) deal with the incentives of a CEO to provide less precise signals about the projects he proposes to the board. Here, in contrast, we assume it is the owners (principal) who determine the signal's precision. Singh (2004), Goldman and Slezak (2006), and Axelson and Baliga (in press) assume there is no uncertainty about the CEO's ability, their focus being the CEO's incentives to distort information. In Singh's model, the issue is the board's ability to obtain accurate signals about the CEO's actions. The primary concern of Goldman and Slezak is how the use of stock-based compensation can induce the CEO to divert effort to manipulating the stock. In contrast, our focus is on the incentives the CEO can have to manipulate information about his ability. In addition, unlike us, Goldman and Slezak treat disclosure rules as exogenous, whereas one of our objectives is to understand how owners *choose* the value-maximizing rules. Axelson and Baliga, like Goldman and Slezak, are interested in how compensation schemes can induce information manipulation by the CEO. In particular, they present a model in which long-term contracts are optimal because short-term measures can be manipulated. But it turns out to be optimal to allow some manipulation of information or lack of transparency because, otherwise, the long-term contracting equilibrium would break down due to *ex post* renegotiation.

Table I: Summary of Analysis

Version of Model	Assumptions	Main Results & Intuition	Implications
Basic	Timing and actions as set forth in Stages 1–5.	• Owners prefer more precise signal • CEO prefers less precise signal • Less than full disclosure can be optimal	*Mandated* increases in disclosure will lead to: • Increases in CEO compensation • Increases in CEO turnover • Decreases in firm value
CEO distorts signal	At a cost to himself, the CEO can boost the signal.	The greater the quality or quantity of information disclosed, the greater the CEO's incentives to distort signal.	If "distortion" corresponds to accounting manipulation or misleading statements, then greater disclosure requirements could lead to more fraud.
Managerial myopia	CEO can boost signal, but not cash flows, and does so in a way that reduces future profits.	Myopia problem is greater the more precise information is.	Direct cost of disclosure: Gives managers incentives to sacrifice future profits to make today look better. Managing "quarter to quarter."
Disclosure of actions (*e.g.*, project selection)	Instead of or in addition to observing signal of CEO's ability, can observe CEO actions	Disclosure of actions can affect inferences about CEO's ability. Can lead to undesirable distortions in action.	Firms can find "opaqueness" with respect to certain actions preferable to transparency.

I The Model

We are concerned with situations in which a firm's owners (more generally, a principal) wish to take an action, a, based on information about the firm or its CEO, $s \in \mathbb{R}$. As will be shown, the owners want more precise information, while the CEO (more generally, an agent) prefers that information be less precise.

A Timing of the Model

The model has the following timing and features.

STAGE 1. The owners of a firm determine the disclosure regime. Such a regime determines the amount of information made available as well as its quality. We assume from the information made available, people can construct a sufficient statistic, s, that has precision q. We will refer to q as the quality of information available. Because, however, more information leads to a more precise statistic, one can equivalently interpret q as a measure of the quantity of information available.[6]

STAGE 2. The owners hire a CEO from a pool of *ex ante* identical would-be CEOs. Let θ denote a measure of the CEO's ability (type) or the quality of the strategy he adopts. We assume θ is an independent random draw from a normal distribution with mean 0 and known variance $1/\tau$ (τ

[6]This follows because there is a monotonic mapping between the amount of information revealed—holding the properties of the information fixed—and the precision of the statistic. So q is measure of the quantity of information revealed. For instance, as is well known (see, *e.g.,* DeGroot, 1970, p. 167) if N random variables x_n are identically and independently distributed normally with unknown mean μ and variance σ^2, where μ is a normally distributed random variable with mean M and variance η^2, then a sufficient statistic for μ is

$$\frac{M\sigma^2 + \eta^2 \sum_{n=1}^{N} x_n}{\sigma^2 + N\eta^2}$$

and its precision is

$$\frac{\sigma^2 + N\eta^2}{\sigma^2\eta^2}$$

So the precision is a function of N, the amount of information revealed.

is the precision of that distribution).[7] Normalizing the mean of the distribution to zero is purely for convenience and is without loss of generality.

STAGE 3. After the CEO has been employed for some period of time, a public signal, s, of θ is realized. The signal is distributed normally with a mean equal to θ and precision q.

STAGE 4. Based on s, the owners update their belief about θ; let $\hat{\theta}$ be their posterior expectation of θ. Based on their posterior beliefs, the owners choose $a \in \mathcal{A} \subset \mathbb{R}$. Denote the owners' cost of action as $c(a)$.

STAGE 5. The CEO gets a payoff (utility) that is—ultimately—a function of $\hat{\theta}$; let $u(\cdot)$ denote that function. Assume it is increasing. A random variable, r, is also realized. Assume $r \sim N(\theta, 1/h)$. Finally, the return to the owners is $rv(a)$. Assume the functions $v(\cdot)$ and $c(\cdot)$ are at least twice differentiable if $\mathcal{A}$ is an interval.

Although bare bones, this model encompasses a number of situations. For instance, suppose that $\mathcal{A} = \{0, 1\}$—keep or fire the CEO—and the CEO has either career concerns or gains a control benefit from retaining his job. Here $v(a) = 1 - a$ and $c(a) = af$, where $f > 0$ is a firing cost. The owners choose $a = 1$ if and only if $\hat{\theta} \geq -f$. Define

$$k(\hat{\theta}) = \begin{cases} 0\,, & \text{if } \hat{\theta} < -f \\ 1\,, & \text{if } \hat{\theta} \geq -f \end{cases} \;;$$

that is $k(\cdot)$ is a function that indicates if the CEO loses his job or keeps it. One way to model $u(\cdot)$ is $u(\hat{\theta}) = bk(\hat{\theta})$, where $b > 0$ is a control benefit the CEO enjoys if and only if he retains his job.

As a second example, suppose the CEO's *future* compensation is an increasing function of his perceived ability. Then $u(\cdot)$ will be a composite function of his utility from income and his compensation as a function of perceived ability.

[7]Ability, θ, is fixed throughout the stages of the model. One concern might, then, be that learning over time about the CEO's ability (as *e.g.,* in repeated version of this model) would be quite rapid. As, however, Holmstrom (1999) shows, one can eliminate rapid learning by allowing θ to follow a random walk across different periods. In fact, as Holmstrom shows, there can be stationarity across periods, so that one might view our game as just one period of a stationary multi-period game.

As a third example, suppose that $\mathcal{A} = \mathbb{R}$ and that a denotes a change in firm size. Without loss of generality, normalize the opportunity cost of funds to zero.[8] Let $v(a) = a$ and $c(a) = a^2/2$ (*i.e.,* quadratic adjustment costs). Given the posterior expectation of r is $\hat{\theta}$, the owners' optimal choice of how much to take out ($a < 0$) or invest further in the firm ($a > 0$) is readily shown to be $a = \hat{\theta}$. Suppose the CEO's utility is increasing in firm size (he prefers to manage a larger empire to a smaller one; he can skim more the more resources under his control; etc.). Then $u(\hat{\theta})$ is his utility (holding the initial size of the firm constant). Note, in this second example, the variable θ could be interpreted either as the CEO's ability or the quality of the strategy he has employed.

B Information

We follow Holmstrom (1999) by assuming that the CEO, like all other players, knows only the *distribution* of his ability or the quality of his strategy. We justify this assumption by assuming either (i) that both the CEO and potential employers learn about his ability from his actual performance (*i.e.,* no one is born knowing whether he'll prove to be a good executive or not); or (ii) that both the CEO and the owners (more precisely, the board of directors) likely hold similar beliefs about how well a given strategy will work because, if their beliefs differed too much, the CEO and the board wouldn't agree to that strategy.

After the signal, s, is observed, the players update their beliefs about θ. The posterior estimates of the mean and precision of the distribution of the CEO's ability are

$$\hat{\theta} = \frac{qs}{q+\tau} \text{ and } \hat{\tau} = \tau + q\,, \tag{1}$$

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

We assumed that the distribution of the signal s given θ is normal with mean θ and variance $1/q$; hence, the distribution of s given the *prior* estimate

[8]One can think of the firm's true returns being $r + R_0$, where R_0 is the return available to the owners from alternative investments (so putting a into the firm costs $R_0 a$ and taking a out returns $R_0 a$). It can readily be seen that setting $R_0 = 0$ is without loss of generality for the analysis at hand.

of θ, 0, is normal with mean 0 and variance $1/q + 1/\tau$.[9] Equivalently, the prior distribution of s is normal with mean 0 and precision

$$\frac{q\tau}{q+\tau}\,.$$

Observe, for future reference, that

$$\hat{\theta} = \frac{q\tau}{q+\tau} \times \frac{s}{\tau}\,. \tag{2}$$

C The Owners' Choice of Action

We assume the owners are risk neutral. Their decision at stage 4 can be written as

$$\max_{a\in\mathcal{A}} \mathbb{E}\{rv(a)|\hat{\theta}\} - c(a) \equiv \max_{a\in\mathcal{A}} \hat{\theta}v(a) - c(a)\,. \tag{3}$$

We limit attention here to $\mathcal{A} = \{0,1\}$ or $\mathcal{A}$ as an interval. Denote the solution to (3) by $a^*(\hat{\theta})$. We assume, for any given $\hat{\theta}$, that (3) has a unique solution.[10] We assume that $a^*(\cdot)$ is not a constant function; that is, the owners' action varies, at least on some margin, with respect to the CEO's estimated ability.

When $\mathcal{A} = \{0,1\}$, we assume that $v(a) = 1 - a$ and $c(a) = af$, where $f > 0$ is a net firing cost (*i.e.,* cost of dismissal less the expected value of a replacement CEO). Hence,

$$a^*(\hat{\theta}) = \begin{cases} 0\,, & \text{if } \hat{\theta} \geq -f \\ 1\,, & \text{if } \hat{\theta} < -f \end{cases}\,. \tag{4}$$

Define the maximized value of (3) given $\hat{\theta}$ as

$$V(\hat{\theta}) \equiv \hat{\theta}v\big(a^*(\hat{\theta})\big) - c\big(a^*(\hat{\theta})\big)\,.$$

[9]The random variable s is the sum of two independently distributed normal variables $s - \theta$ (*i.e.,* the error in s) and θ; hence, s is also normally distributed. The means of these two random variables are both zero, so the mean of s is, thus, 0. The variance of the two variables are $1/q$ and $1/\tau$ respectively, so the variance s is $1/q + 1/\tau$.

[10]This assumption would, for instance, be satisfied if we assumed the function to be maximized was strictly quasi-concave and bounded and that, when $\mathcal{A}$ is an interval, it is an interval of finite length.

Lemma 1 *Maintain the assumptions given above. Assume that either $\mathcal{A}$ is $\{0,1\}$ or it is an interval. Then $V(\cdot)$ is a convex, but not affine, function. Moreover, when $\mathcal{A}$ is an interval, $a^*(\cdot)$ is a non-decreasing function.*

Observe that Lemma 1 is essentially stating that the owners find information to be valuable; that is, the action they take, a^*, potentially varies with their posterior estimate of θ. If it did not vary, then $V(\cdot)$ would be a straight line. Because it does vary and maxima are unique, $V(\cdot)$ must lie above—over at least some interval—its tangency line at any specific point; that is, it must be convex.

A consequence of Lemma 1 is that the owners are risk *loving* in $\hat{\theta}$. Hence, if one distribution over $\hat{\theta}$ is a mean-preserving spread of a second, then the owners strictly prefer the first to the second. Recall that the prior distribution of the signal, s, is normal with mean zero and variance $1/q+1/\tau$. From (1), it follows that the prior distribution of $\hat{\theta}$ is normal with mean zero and variance

$$\operatorname{Var}(\hat{\theta}) = \frac{q^2}{(q+\tau)^2}\operatorname{Var}(s) = \frac{q\tau}{\tau^2(q+\tau)}\,. \tag{5}$$

It is readily seen this increasing in q. Recalling that a mean-preserving spread of a normally distributed random variable is equivalent to an increase in its variance, we have established:

Proposition 1 *The firm's owners strictly prefer a greater precision in the signal (a larger q) to a lesser precision (a smaller q),* ceteris paribus.

D The CEO's Preferences

We now turn to the CEO. We consider two possible sets of assumptions about the CEO's preferences.

In the first, we assume that $\mathcal{A} = \{0,1\}$ and the CEO loses $\ell > 0$ if fired (*i.e.,* the owners choose $a = 1$). For instance, ℓ could represent lost status, lost benefits of control, or the reduction in future salary if the owners fire the CEO. Consequently, in this case

$$u(\hat{\theta}) = \begin{cases} -\ell\,, & \text{if } \hat{\theta} < -f \\ 0\,, & \text{if } \hat{\theta} \geq -f \end{cases} \tag{6}$$

plus, possibly, an additive constant, which we are free to ignore. Note the use of (4) in deriving (6). Recall that the prior distribution of $\hat{\theta}$ is normal with mean zero and variance given by (5). For this case, this means that

$$\mathbb{E}\{u(\hat{\theta})\} = -\ell\Phi\left(\frac{-f}{\sqrt{\mathrm{Var}(\hat{\theta})}}\right), \tag{7}$$

where $\Phi(\cdot)$ is the distribution function for a standard normal random variable (*i.e.,* one with mean zero and variance one). Differentiating the righthand side of (7) with respect to q yields

$$\frac{d\mathbb{E}\{u(\hat{\theta})\}}{dq} = -f\ell\phi\left(\frac{-f}{\sqrt{\mathrm{Var}(\hat{\theta})}}\right)\frac{1}{\mathrm{Var}(\hat{\theta})^{3/2}} \times \frac{\partial\,\mathrm{Var}(\hat{\theta})}{\partial q}, \tag{8}$$

where $\phi(\cdot)$ is the density function of a standard normal. The sign of (8) is negative (recall $\mathrm{Var}(\hat{\theta})$ is increasing in q). Expression (8), thus, reveals that the CEO's utility falls as the signal becomes more precise. This makes intuitive sense: Absent information, the owners take no action; but as the signal becomes informative, the CEO is increasingly vulnerable to the owners' acting on this information and losing ℓ. This establishes part (i) of Proposition 2 below.

In the second set of assumptions about CEO preferences, we simply assume that $u(\hat{\theta})$, the CEO's payoff if the posterior estimate of θ is $\hat{\theta}$, exhibits diminishing marginal utility. That is, *ex ante*, the CEO is risk averse with respect to $\hat{\theta}$. This, for instance, would be the case if the CEO is risk averse over income and his future salary is an affine or concave function of his estimated ability (*e.g.,* the model is a career-concerns model along the lines of Holmstrom, 1999). The CEO is risk averse and, as shown above, an increase in q corresponds to a mean-preserving spread of $\hat{\theta}$, These two facts imply part (ii) of the following proposition.

Proposition 2 *Under the assumptions of the model,*

(i) if the CEO *suffers a loss in utility from being dismissed (i.e., his utility is given by (6)); or*

(ii) if his utility as a function of his estimated ability exhibits diminishing marginal utility in his estimated ability,

then the CEO *strictly prefers a less precise signal (lower q) to a more precise signal (higher q),* ceteris paribus.

Propositions 1 and 2 together imply that the owners and CEO are at odds about the quality of reporting in the firm; the owners prefer greater quality and the CEO less.

It may, at first, seem counter-intuitive that a more precise signal about θ increases risk. Wouldn't a risk-averse CEO prefer a more precise signal about his ability or the quality of his strategy to a less precise signal? To understand why the answer is no, consider the extreme of a signal that was pure noise. No one would update his or her estimate of the CEO's ability upon seeing this signal; that is, the posterior estimate would just be the prior estimate. The prior estimate, by definition, is fixed, so the CEO would be exposed to no risk. Now consider the other extreme, the signal has no noise. In this case, the posterior is very sensitive to the realization of the signal, which is still a random variable *ex ante*. In other words, from an *ex ante* perspective, the CEO can anticipate a lot of variance in the posterior estimate of his ability. He is, thus, exposed to considerable risk. Moreover, because from an *ex ante* perspective the expected posterior estimate is the prior estimate, the situation with a noiseless signal is a mean-preserving spread of the situation with an infinitely noisy signal. Being risk averse, the CEO prefers the latter to the former. This relation between signal noise and the CEO's expected utility is monotone: As the signal becomes noisier, the posterior estimate becomes more a function of the prior estimate of the CEO's ability, which recall is fixed, and less of the signal, s, which is random. Being risk averse, the CEO prefers more weight be put on the fixed quantity than on the random quantity (recall $\mathbb{E}\{s\} = 0$). The *less* precise the signal, the more weight is put on the prior estimate, making the CEO better off.

E Determination of Compensation at Initial Hiring

We now consider the setting of the CEO's compensation, w, at stage 2. Suppose the CEO's overall expected utility, including compensation, is

$$\mathbb{E}\big\{u(\hat{\theta})\big|q\big\} + y(w)\,, \tag{9}$$

where $y : \mathbb{R} \to \mathbb{R}$ is his utility for money.[11] People prefer more money to less, so $y(\cdot)$ is increasing. We take it to be differentiable as well. Assume there is

[11]Additively separable utility is a standard assumption. When $u(\hat{\theta})$ derives from the CEO's future income, we can imagine that $u(\hat{\theta}) = \delta y\big(w(\hat{\theta})\big)$, where δ is the discount factor and $w(\cdot)$ is the mapping from estimated ability to future compensation.

a participation constraint for the CEO; his expected utility must not be less than $\bar{u}$. Note, depending on the bargaining, this constraint may or may not bind in equilibrium.

The owners' expected payoff is

$$\mathbb{E}\{V(\hat{\theta})|q\} - w\,. \tag{10}$$

Their participation constraint is that they not lose money in expectation.

Suppose wage bargaining is generalized Nash bargaining. That is, w is chosen to maximize

$$\lambda \log\Big(\mathbb{E}\{V(\hat{\theta})|q\} - w\Big) + (1-\lambda)\log\Big(\mathbb{E}\{u(\hat{\theta})|q\} + y(w) - \bar{u}\Big)\,, \tag{11}$$

where $\lambda \in [0,1]$ is the owners' bargaining power and $1-\lambda$ is the CEO's. Participation constraints bind only if $\lambda = 1$ or $\lambda = 0$.

Proposition 3 *Assume wage bargaining is generalized Nash. Then the CEO's compensation, as determined by the bargaining process is non-decreasing in how precise the owners make information (i.e., non-decreasing in q). Moreover, if the CEO's compensation is positive at given precision of information, then an increase in precision will strictly increase his his compensation.*[12]

Proposition 3 can be extended to other bargaining games.

Intuition for this result can be gained by considering the two bargaining extremes. If the owners have all the bargaining power, they will hold the CEO to his reservation utility. Hence, any reduction in $\mathbb{E}\{u(\hat{\theta})|q\}$ must be compensated with an increase in w to keep the CEO at his reservation utility. Conversely, if the CEO has all the bargaining power, then he captures all the owners' expected profit through his compensation. If the owners' expected profit goes up, as would follow if the precision of the information is increased, then there is more for the CEO to capture and, hence, the greater is his compensation. In between these extremes, the result follows because both forces are at work: An increase in the precision of information generates more expected profit, which will be divided between owners and the CEO through the bargaining process; and, because such an increase directly harms the CEO, it warrants some offsetting compensation for the CEO. The two forces act in tandem to boost the compensation that the CEO receives.

[12] If we assumed that $y'(w) \to \infty$ as $w \to 0$, then the CEO's compensation would always be positive if $\lambda < 1$.

It follows that when the owners choose the information regime (*i.e.*, q), they will wish to take into account the impact of q on the compensation they must pay the CEO.

For example, suppose that a is the change in firm size. Let $v(a) = a$ and let $c(a) = a^2/2$ be the adjustment cost. It is readily seen that $a^*(\hat{\theta}) = \hat{\theta}$ and $\mathbb{E}\{V(\hat{\theta})\} = \frac{1}{2}\operatorname{Var}(\hat{\theta})$. Suppose that the CEO's utility is $\beta w - \exp(-a)$, $\beta > 0$; that is, he values compensation, w, and prefers to grow the firm rather than shrink it, *ceteris paribus*. Observe $u(\hat{\theta}) = -\exp(-\hat{\theta})$ and, therefore, that

$$\mathbb{E}\{u(\hat{\theta})\} = -\exp\left(\frac{1}{2}\operatorname{Var}(\hat{\theta})\right).$$

Normalize the CEO's reservation utility to zero.

Suppose bargaining power is equally divided between the parties (*i.e.*, $\lambda = 1/2$). It follows that w satisfies the first-order condition:

$$\frac{-1}{\frac{1}{2}\operatorname{Var}(\hat{\theta}) - w} + \frac{\beta}{\left(-\exp\left(\frac{1}{2}\operatorname{Var}(\hat{\theta})\right) + \beta w\right)} = 0\,.$$

Solving for w yields

$$w = \frac{1}{2\beta}\left(\exp\left(\frac{1}{2}\operatorname{Var}(\hat{\theta})\right) + \beta\frac{1}{2}\operatorname{Var}(\hat{\theta})\right). \tag{12}$$

Given that $\operatorname{Var}(\hat{\theta})$ is an increasing function of q, the owners' problem can be expressed as choosing $\operatorname{Var}(\hat{\theta})$ to solve

$$\max_{\operatorname{Var}(\hat{\theta})} \mathbb{E}\{V(\hat{\theta})\} - w \equiv \max_{\operatorname{Var}(\hat{\theta})} \frac{1}{4}\operatorname{Var}(\hat{\theta}) - \frac{1}{2\beta}\exp\left(\frac{1}{2}\operatorname{Var}(\hat{\theta})\right) \tag{13}$$

subject to $\operatorname{Var}(\hat{\theta}) \leq 1/\tau$.[13] Expression (13) is strictly concave (*i.e.*, the first-order condition is also sufficient) and the program has the following solution:

$$\operatorname{Var}(\hat{\theta}) = \begin{cases} 0\,, \text{ if } \beta \leq 1 \\ 2\log(\beta)\,, \text{ if } 1 < \beta < \exp\left(\frac{1}{2\tau}\right) \\ 1/\tau\,, \text{ if } \exp\left(\frac{1}{2\tau}\right) \leq \beta \end{cases}.$$

[13] From (5), $\lim_{q\to\infty}\operatorname{Var}(\hat{\theta}) = 1/\tau$.

In terms of q, this answer translates to

$$q^* = \begin{cases} 0\,, \text{ if } \beta \leq 1 \\ \frac{2\tau^2 \log(\beta)}{1-2\tau\log(\beta)}\,, \text{ if } 1 < \beta < \exp\left(\frac{1}{2\tau}\right) \\ \infty\,, \text{ if } \exp\left(\frac{1}{2\tau}\right) \leq \beta \end{cases} . \tag{14}$$

It follows that if the CEO cares relatively little about compensation *vis-à-vis* a change in firm size (*i.e.,* $\beta \leq 1$), then firm owners will choose to have no information about the CEO's ability released to them (equivalently, release signals that are pure noise). Even if the CEO cares relatively a lot about his compensation (*i.e.,* $\beta > 1$), as long as there is sufficient prior uncertainty about ability (*i.e.,* τ is small), the owners will not wish to have the maximum amount or perfect quality of information released to them. Instead, they will tradeoff the value of more informative signals against the impact that this greater informativeness will have on the CEO's compensation. Only when there is relatively little uncertainty *ex ante* about the CEO's ability (τ is large), in which case the CEO's exposure to risk is relatively unaffected by q,[14] would the owners wish to maximize the amount (equivalently, quality) of information that is available to them.

Observe that, in equilibrium, the owners tend to have a more informative information regime when there is little uncertainty about the CEO's ability than when there is considerable uncertainty. This might, at first, seem backward: Isn't the value of additional information about the CEO's ability greater the more uncertainty there is about his ability *ex ante*? The answer is yes; but because this information has a greater negative effect on the CEO's well-being the greater the *ex ante* uncertainty, the more compensation the CEO will get, and the cost of this greater compensation outweighs the greater value of this information. This somewhat perverse finding underscores the importance of taking an equilibrium approach to governance; in particular, because some policy is beneficial to the owners ignoring equilibrium adjustments doesn't mean it will be beneficial to them once the equilibrium adjustments are accounted for.

How might we assess the economic importance of this analysis? Absent knowledge of the correct utility function for the CEO, the question cannot be definitively answered. We can, however, provide some calculations. Suppose

[14]The cross-partial derivative of $\text{Var}(\hat{\theta})$ with respect to q and τ is $-2/(q+\tau)^3$, so the marginal effect on $\text{Var}(\hat{\theta})$ from a change in q is smaller in magnitude the greater is τ.

$\lambda = 9/10$ (owners have most of the bargaining power) and $\beta = 50$ (the CEO weights his pay at 50 : 1 relative to his utility from firm size). Working in millions of dollars, suppose that the standard deviation of ability, $1/\sqrt{\tau}$, is $\sqrt{10}$. Solving the model, we find that the owners optimally set $q \approx .360$, leading to compensation of \$1.29 million and an expected value of the firm gross of compensation of \$3.91 million.[15] Firm value, gross of compensation, if the owners maximized their information (i.e., set $q \to \infty$) would be \$5 million. If they did so, however, they would need to pay the CEO \$3.17 million.

F Firm Size, Level of Disclosure, and Executive Pay

One question that could be asked is how does the analysis change with firm size?[16] To answer the question, let the owners' payoff be $M\big(rv(a) - c(a)\big)$, where M is a measure of firm size.[17] It is readily seen that owners' maximized payoff as a function of the posterior estimate of ability, $\hat{\theta}$, is

$$MV(\hat{\theta}) \equiv M\Big(\hat{\theta}v\big(a^*(\hat{\theta})\big) - c\big(a^*(\hat{\theta})\big)\Big)\,.$$

Hence, generalized Nash bargaining over the wage will satisfy the first-order condition

$$0 = \frac{-\lambda}{M\mathbb{E}\big\{V(\hat{\theta})\big|q\big\} - w} + \frac{(1-\lambda)y'(w)}{\mathbb{E}\big\{u(\hat{\theta})\big|q\big\} + y(w) - \bar{u}}\,.$$

This can be rewritten as

$$\Lambda \equiv \frac{\lambda}{1-\lambda} = \frac{\Big(M\mathbb{E}\big\{V(\hat{\theta})\big|q\big\} - w\Big)y'(w)}{\mathbb{E}\big\{u(\hat{\theta})\big|q\big\} + y(w) - \bar{u}}\,. \qquad (15)$$

Provided marginal utility of income, $y'(\cdot)$, is a non-increasing function, it is readily seen from (15) that an increase in firm size, M, must lead to an increase in CEO pay, w, holding disclosure policy constant. To summarize:

[15] Note this is expected firm value due solely to the owners' acting in response to the information they receive; in all likelihood, there are components of firm value that are independent of this.

[16] We thank an anonymous referee for posing this question.

[17] We could also let the owners' payoff be $Mrv(a) - c(a)$. The analysis is slightly more cumbersome, but the conclusions are the same. For expositional ease, therefore, we chose the specification given in the text.

Lemma 2 *If the marginal utility of income is non-increasing and disclosure policy is held constant, then an increase in firm size results in an increase in* CEO *pay.*

Of course, there is no reason to expect disclosure policy to be held constant as firm size changes. In fact, we can show that the precision of information will increase with firm size under certain circumstances:

Proposition 4 *Assume generalized Nash bargaining. If the marginal utility of income ($y'(\cdot)$) is constant or log concave, then a larger firm has a greater level of disclosure (higher precision information) and pays its* CEO *more compared to a smaller firm.*

Intuitively, the more precise the information, the greater is the firm's expected value. This value is magnified when the firm is larger, so a larger firm gains more from an increase in precision than a smaller firm. This will tend to make larger firms choose higher levels of disclosure. But what about the consequent effect on the CEO's compensation? From Lemma 2, a larger firm is already paying its CEO more; hence, the question is whether the rate of increase in that compensation from a higher level of disclosure is greater at higher levels of pay than lower levels. If it is and pay is rising sufficiently quickly, then a larger firm would wish to lower the level of disclosure. The assumptions made on the *marginal* utility of income—specifically that it not be "too convex"—rule out that scenario.

II CEO Efforts to Distort the Signal

Since the CEO's welfare is affected by the signal, he has incentives to take actions that affect the signal that is received. In this section, we explore how the CEO's efforts could be affected by the quality of information disclosed by the firm. What we seek to capture by such effort are actions that the CEO might take to boost the numbers. These include activities such as the timing of earnings announcements, aggressive accounting, and actually "cooking the books." For the moment, we assume that such effort has no direct effect on profits.

A Assumptions

Denote the CEO's effort by $x \in \mathbb{R}_+$. We assume such effort enhances the signal; specifically, assume the observed signal is $\tilde{s} = s + x$. How much effort the CEO expends is his private information, although, as we will show, the owners will correctly infer what the CEO does on the equilibrium path.

Assume that the CEO chooses x prior to the realization of the signal, and that he finds such effort costly; let $d(\cdot)$ denote the cost of effort (his disutility of effort). In addition, assume that this cost enters the CEO's utility function additively; that $d(\cdot)$ is twice differentiable on $\mathbb{R}_+$; that no effort is "free" (*i.e.,* $d(0) = 0$); that there is a positive marginal cost to effort (*i.e.,* $d'(\cdot) > 0$ on $(0, \infty)$); and that this marginal cost is rising in effort ($d''(\cdot) > 0$). Finally, assume $\lim_{x \to \infty} d'(x) = \infty$.

Ignoring compensation, the CEO's utility is, therefore,

$$u(\hat{\theta}) - d(x)\,. \tag{16}$$

B Equilibrium

We focus on pure-strategy equilibria. In a pure-strategy equilibrium, the CEO doesn't fool anyone on the equilibrium path: owners infer the x he chooses and use $s = \tilde{s} - \hat{x}$ as the signal, where $\hat{x}$ is the value of x that they infer. Note, from (2), that

$$\hat{\theta} = \frac{1}{\tau \operatorname{Var}(s)}(\tilde{s} - \hat{x}) = \frac{1}{\tau \operatorname{Var}(s)}(s + x - \hat{x})\,.$$

Given that $\hat{x}$ is inferred effort and x is actual effort, the CEO chooses x to maximize

$$\int_{-\infty}^{\infty} u\left(\frac{1}{\tau \operatorname{Var}(s)}\big(s + x - \hat{x}\big)\right) \frac{1}{\sqrt{2\pi \operatorname{Var}(s)}} \exp\left(-\frac{1}{2\operatorname{Var}(s)} s^2\right) ds - d(x) \tag{17}$$

Observe that (17) is globally concave in x; hence, the solution to (17) is unique. Making the change of variables $z = s/\sqrt{\operatorname{Var}(s)}$, (17) can be written as

$$\int_{-\infty}^{\infty} u\left(\frac{z}{\tau\sqrt{\operatorname{Var}(s)}} + \frac{x - \hat{x}}{\tau \operatorname{Var}(s)}\right) \phi(z) dz - d(x)\,, \tag{18}$$

where $\phi(\cdot)$ is, again, the density function for a standard normal distribution.

In equilibrium, the inferred value and the chosen value must be the same. Hence, the equilibrium value, x_E, is defined by the first-order condition for maximizing (18) when $\hat{x} = x_E$:

$$0 \geq \int_{-\infty}^{\infty} \frac{1}{\tau\,\mathrm{Var}(s)} u' \left(\frac{z}{\tau\sqrt{\mathrm{Var}(s)}} \right) \phi(z)dz - d'(x_E)\,, \tag{19}$$

where $x_E = 0$ if it is an inequality. Lemma A.2 in the Appendix rules out the possibility that the integral in (19) is infinite. Consequently, because $d'(x) \to \infty$ as $x \to \infty$, it follows that $x_E < \infty$.

We have the following comparative statics:

Proposition 5 *If the coefficient of absolute risk aversion for the* CEO*'s utility function is non-increasing, then*

(i) the CEO*'s efforts to exaggerate performance are non-decreasing in reporting quality and strictly increasing if* $x_E > 0$*; and*

(ii) the CEO*'s efforts to exaggerate performance are non-increasing in the precision (i.e.,* τ*) of the prior* θ *and strictly decreasing if* $x_E > 0$*.*

Why attitudes to risk matter can be seen intuitively by considering expression (19). Note that an increase in τ or $\mathrm{Var}(s)$ decreases marginal utility for $z < 0$, but increases marginal utility for $z > 0$. If this second effect were strong enough, it could dominate the other effects. Assuming the coefficient of absolute risk aversion to be non-increasing rules out that possibility. It is a common contention in economics that individuals exhibit non-increasing coefficients of absolute risk aversion (see, *e.g.,* the discussion in Hirshleifer and Riley, 1992).

The intuition behind Proposition 5(i) is as follows. An increase in the precision of the signal, s, increases the weight placed on the signal with respect to constructing the posterior estimate, which means the CEO's utility is more sensitive to the signal. Hence, the CEO's incentives to exaggerate the signal are greater. Similar intuition lies behind Proposition 5(ii) because an increase in the precision of the prior estimate of ability, τ, *reduces* the weight placed on the signal with respect to constructing the posterior estimate.

C Managerial Myopia

Here we apply the ideas of this section to the fear that managers behave myopically. To so, we extend our a model to incorporate ideas from Stein (1989).

Assume the CEO holds a relatively small fraction of the firm's stock. The fraction itself is immaterial because it can be folded into the CEO's utility function. Let $U(y) = -e^{-\xi}$ denote the CEO's utility function when the firm's payout is ξ (setting the coefficient of absolute risk aversion to 1 is merely for convenience; it has no impact on the analysis). The owners are risk neutral, so their payoff is simply ξ (technically, proportional to that given that the CEO owns some shares).

Assume the following timing. After Stage 2, but prior to Stage 3, the CEO takes actions that raise the signal by x (*e.g.,* he takes actions to boost orders). These actions reduce, however, final payout by $x^2/2$ (*e.g.,* orders have been boosted by offering secret rebates to major customers). After Stage 3, but prior to Stage 5, an outside firm could make a bid for the firm in question.[18] Assume this happens with probability ρ, $0 < \rho < 1$. The bid is for 100% of the shares and the total value of the bid equals the expected payout of the firm were it not taken over. Given the owners' indifference between keeping and selling their shares, we can assume that they sell; that is, should there be a takeover bid, it will be successful.

As before, let $\hat{x}$ denote the anticipated value of x. The CEO's expected utility is, thus,

$$\rho\mathbb{E}\left\{U\Big(\frac{1}{\tau\,\mathrm{Var}(s)}(s + x - \hat{x}) - \frac{\hat{x}^2}{2}\Big)\right\} + (1-\rho)\mathbb{E}\left\{U\Big(r - \frac{x^2}{2}\Big)\right\} . \tag{20}$$

Dividing both sides of (20) by ρ does not change the CEO's optimization problem. Hence, we can define

$$d(x) = -\frac{1-\rho}{\rho}\mathbb{E}\left\{U\big(r - \frac{x^2}{2}\big)\right\} .$$

It is readily verified that $d'(0) = 0$, $d'(x) > 0$ if $x > 0$, and $d''(x) > 0$, as previously assumed.

[18]As Stein notes (p. 659), there are other interpretations of his model beside managerial stock ownership and a takeover threat. One alternative is a need for funds that necessitates issuing new stock. See Stein for a complete discussion.

Substituting in for $U(\cdot)$, the CEO chooses x to maximize

$$-\exp\left(\frac{1}{2\tau^2\operatorname{Var}(s)}\right)\exp\left(-\frac{1}{\tau\operatorname{Var}(s)}(x-\hat{x})+\frac{\hat{x}^2}{2}\right)-\frac{1-\rho}{\rho}\exp\left(\frac{1}{2}\sigma_r^2\right)\exp\left(\frac{x^2}{2}\right), \tag{21}$$

where σ_r^2 is the prior variance of r and where we've made use of the fact that $\mathbb{E}\{e^{-\zeta}\}=e^{\frac{1}{2}\operatorname{Var}(\zeta)}$ if ζ is a mean-zero normal random variable. Differentiating (21) with respect to x yields the first-order condition

$$\frac{1}{\tau\operatorname{Var}(s)}\exp\left(\frac{1}{2\tau^2\operatorname{Var}(s)}\right)\exp\left(-\frac{1}{\tau\operatorname{Var}(s)}(x-\hat{x})+\frac{\hat{x}^2}{2}\right) \\ -x\frac{1-\rho}{\rho}\exp\left(\frac{1}{2}\sigma_r^2\right)\exp\left(\frac{x^2}{2}\right)=0\,. \tag{22}$$

It is readily seen that the second-order conditions are met; indeed, that (21) is globally concave in x. The solution to (22) is unique and, in equilibrium, it must be $\hat{x}$; hence, rearranging and canceling common terms, the equilibrium value of x, x_E, is

$$x_E=\frac{\rho}{1-\rho}\frac{1}{\tau\operatorname{Var}(s)}\exp\left(\frac{1}{2}\Big(\frac{1}{\tau^2\operatorname{Var}(s)}-\sigma_r^2\Big)\right)\,. \tag{23}$$

It is quickly verified that x_E is decreasing in $\operatorname{Var}(s)$ and, thus, *increasing* in q, the quality (or quantity) of information.

The owners' *a priori* expected payoff in equilibrium is $-x_E^2/2$ (to be technical, proportional to that given the CEO holds some shares). It follows that the owners want x_E to be as small as possible. From (23) that implies they want q to be as small as possible; in fact, ideally, they would want to make the signal infinitely noisy or, equivalently, to commit to suppressing it all together.

To summarize

Proposition 6 *Under this model of managerial myopia, the cost to the owners of managerial myopia is increasing in the quality or quantity of publicly available information (i.e., q).*

Proposition 6 is somewhat striking insofar as it provides a justification for making less information available when the stock trades publicly and the CEO has a financial interest in the value of the stock. As long as information remains symmetric, less information could make for a more valuable firm. Of course, the analysis in this section abstracts away from other reasons why owners would wish to gain information (*e.g.,* to evaluate the CEO), so the conclusion of Proposition 6 should be understood as identifying *one* factor relevant to the debate about the optimal amount of disclosure.

III Information About Actions

Based on performance signals, market participants draw inferences about the CEO's underlying abilities and, where relevant, his actions. So far, decisions about disclosure have concerned the precision of such signals. Alternatively, instead of a signal about the CEO's ability, the firm could make visible the actions the CEO actually takes. In this section, we consider the costs and benefits of such disclosure; in particular, we focus on some of the perverse incentives that can be created if the CEO's actions are visible to market participants.[19]

Our model considers the issue of whether revealing details about what the CEO is doing can adversely affect the owners. To do so, we modify our earlier model as follows:

STAGE 1. The owners of a firm decide whether details of the CEO's action will be made publicly available (disclosed) or kept secret. As before, the owners also hire a CEO from a pool of *ex ante* identical would-be CEOs and make a take-it-or-leave-it offer to him. As before, the CEO is of unknown ability.

STAGE 2. The CEO selects an action x from the set of potential actions $\mathcal{X}$. What is revealed publicly about this action depends on the owners' choice of disclosure regime. An action might be choice of a project, policy, or strategy.

STAGE 3. The owners' return, r, is realized. This is the basis of the posterior estimate of the CEO's ability, $\hat{\theta}$. Assume

$$r = \theta + \mu_x + \varepsilon_x \, ,$$

[19] Our analysis is closely related to Holmstrom and Ricart i Costa (1986). They, however, focus only on the case of hidden action by the CEO, whereas we also explore the case of observable action. Consequently, they don't address our central issue of what the optimal disclosure policy should be.

where μ_x is the intrinsic mean return from action x and ε_x is an error term associated with project x. Assume $\varepsilon_x \sim N(0, 1/h_x)$. Note

$$\mathrm{Var}(r) = \frac{1}{\tau} + \frac{1}{h_x} = \frac{h_x + \tau}{h_x \tau}\,.$$

Observe there is no signal s in this version of the model. To ensure maxima exist, we assume $\mathcal{X}$ is compact.

Consider, first, the case in which there is complete disclosure, so the public observes the CEO's action fully, which we assume to mean that the public knows μ_x and h_x. From (1), the posterior estimate of ability is

$$\hat{\theta} = \frac{h_x(r - \mu_x)}{\tau + h_x}\,.$$

The *ex ante* distribution of $\hat{\theta}$ is, therefore,

$$\hat{\theta} \sim N\left(0, \frac{h_x}{\tau(h_x + \tau)}\right)\,. \tag{24}$$

From (24), it follows that $\mathrm{Var}(\hat{\theta})$ is *increasing* in h_x and that $\mathbb{E}\{\hat{\theta}\}$ is invariant with respect to μ_x or h_x. Given that the CEO's utility is concave in $\hat{\theta}$, this proves

Lemma 3 *Assume complete disclosure of information about project choice. Then among all the possible projects available, the* CEO *most prefers the riskiest project (i.e., the $x \in \mathcal{X}$ that maximizes* $\mathrm{Var}(\varepsilon_x)$*) ceteris paribus.*

The intuition behind Lemma 3 is the same as that behind Proposition 2: As there, the CEO's future payoff is a function of a weighted average of the prior estimate of θ, which is fixed, and the outcome, here r, which is random. Since a risk-averse CEO prefers that more weight be put on the non-random component than on the random component in the posterior estimates of his ability, he will choose, more than is in shareholders' interests, volatile actions that reveal relatively little about his ability.

Consider, next, the case in which there is no disclosure and the CEO's choice of action is his private information. From (1), the posterior estimate of ability is

$$\hat{\theta} = \frac{h_{\hat{x}}(\theta + \varepsilon_x + \mu_x - \mu_{\hat{x}})}{\tau + h_{\hat{x}}}\,, \tag{25}$$

where $\hat{x}$ is the action that the public *believes* the CEO to have taken and x is the action he actually takes (in equilibrium the two must be the same). The *ex ante* distribution of $\hat{\theta}$ is, therefore,

$$\hat{\theta} \sim N\left(\frac{h_{\hat{x}}(\mu_x - \mu_{\hat{x}})}{\tau + h_{\hat{x}}}, \left(\frac{h_{\hat{x}}}{\tau + h_{\hat{x}}}\right)^2 \left(\frac{h_x + \tau}{h_x \tau}\right)\right). \tag{26}$$

Suppose that the intrinsic mean (*i.e.,* μ) did not vary across actions. Then, as was the case with complete disclosure, all the CEO would be concerned with would be the variance of $\hat{\theta}$. From (26), $\text{Var}(\hat{\theta})$ is decreasing in h_x; that is, contrary to the case of complete disclosure (*i.e.,* Lemma 3), when there is no disclosure, then the CEO prefers the least risky action *ceteris paribus.* To summarize

Proposition 7 *The* CEO*'s attitude towards risky actions changes depending on whether there is disclosure of his choice of action or not; with the* CEO *favoring more risk given disclosure and less risk absent disclosure, ceteris paribus.*

Proposition 7 might, at first, seem at odds with the claim that greater disclosure causes managers to take *less* risk. The two can be reconciled, however, if one recognizes that—under complete disclosure—taking no action and taking an infinitely risk action are statistically equivalent. If the manager takes no action, then there is no opportunity to update the estimate of his ability and he is, thus, exposed to no risk. Likewise, if he chose an infinitely risky action—corresponding to zero precision, $h_x = 0$—then, from (24), there would also be no variance—and thus risk—attached to that action. To summarize:

Corollary 1 *If, given disclosure, the manager can be seen to have taken no action, then taking no action is his best strategy.*

In what follows, it will help to keep the notation manageable if we define

$$\omega_x = \frac{h_x}{\tau + h_x}.$$

Observe ω_x varies monotonically in h_x. With this notation, expressions (24) and (26) become, respectively,

$$\hat{\theta} \sim N\left(0, \frac{\omega_x}{\tau}\right) \tag{24'}$$

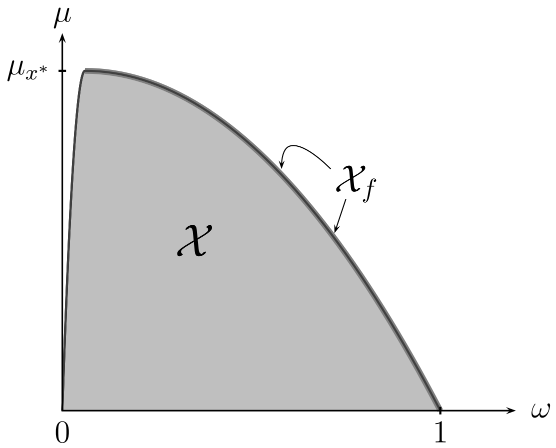

Figure 1: Set of possible actions, $\mathcal{X}$. The set of possible actions chosen under no disclosure lie on the eastern frontier, $\mathcal{X}_f$. Expected return and risk are greater with no disclosure than disclosure.

(complete disclosure) and

$$\hat{\theta} \sim N\left(\omega_{\hat{x}}(\mu_x - \mu_{\hat{x}}), \frac{\omega_{\hat{x}}^2}{\tau\omega_x}\right) \tag{26'}$$

(no disclosure).

Because ω_x is monotonic with h_x, there is no loss in conceiving of the set of possible actions, $\mathcal{X}$, as being a subset of "safety-return" space; that is, the space with safety, ω, on the horizontal axis and mean return, μ, on the vertical. Figure 1 illustrates. We assume no action—which recall is equivalent to $(0, 0)$—is in $\mathcal{X}$. We assume, however, that no actual action can be infinitely risky, so $(0, \mu) \notin \mathcal{X}$, $\mu > 0$. Finally, to avoid mathematical complications that have no real economic consequences, we assume that $\mathcal{X}$ is convex.

We now consider the optimal disclosure regime. The analysis when the CEO's action is completely unobservable is similar to the analysis in Section II: All else equal, the CEO has an incentive to choose actions with high intrinsic mean returns. The problem could be, however, that it is not all else equal; in particular, higher mean returns could correspond to greater risk, which the CEO finds costly under a no-disclosure regime. In other words, the CEO faces a tradeoff between risk and return when his action is not disclosed.

Define the following subsets of $\mathbb{R}$.

$$M(\omega) = \max\{\mu|(\omega,\mu) \in \mathcal{X}\}$$

and

$$\Omega(\mu) = \max\{\omega|(\omega,\mu) \in \mathcal{X}\}\,.$$

Define the following frontier of $\mathcal{X}$.

$$\mathcal{X}_f = \big\{(\omega,\mu)|\omega \in \Omega(\mu) \text{ and } \mu \in M(\omega)\big\}\,.$$

Figure 1 illustrates.

Lemma 4 *Under complete non-disclosure of managerial actions, the manager chooses an $x \in \mathcal{X}_f$.*

Because (i) $(0,0) \in \mathcal{X}$ and (ii) $(0,0)$ is the manager's most preferred "action" given disclosure, it follows from Lemma 4 that the firm's expected return and risk are greater with no disclosure than with complete disclosure. (Greater risk follows because we can interpret $(0,0)$ as equivalent to no action.) To summarize:

Proposition 8 *Suppose the manager can take no action (i.e., choose $(0,0)$). Then the firm's expected returns and risk are greater under no disclosure than complete disclosure.*

Even if the manager has to take an action (it is impossible not to an action), it can remain true that the firm's expected returns are greater under no disclosure than complete disclosure; Figure 2 illustrates this. Risk, however, will—in this case—be greater with disclosure. On the other hand, an alternative scenario is illustrated Figure 3; now $(0,0)$ is absent from $\mathcal{X}$ and ω is bounded below by η. As an example of this scenario, imagine the manager runs an investment firm. He must make investments. Given disclosure, he chooses the riskiest investment strategy (and greatest expected return); absent disclosure, the manager is more cautious.

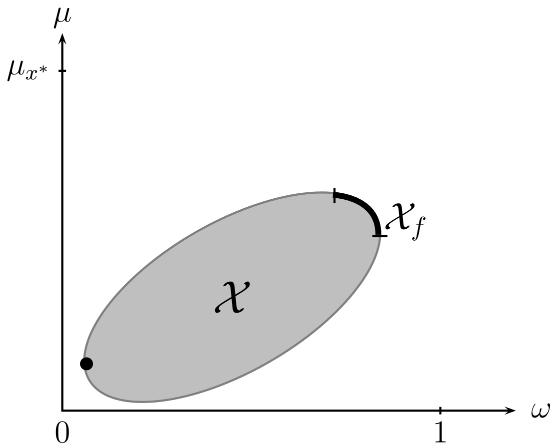

Figure 2: Situation in which no disclosure yields higher expected returns and less risk than complete disclosure. (Under disclosure, the CEO chooses the indicated point on the left end of $\mathcal{X}$.)

A Contracting

The preceding analysis ignored the issue of contracts between the owners and the CEO. If the parties could write contracts contingent on the CEO's action, then any action could be implemented if actions must be disclosed. It is worth noting, however, that the action that would be implemented is not necessarily the highest-return action (the one corresponding to μ_{x^*} in Figures 1–3). Let x^* be the highest-return action. Suppose the frontier of $\mathcal{X}$ is concave in ω at x^* (as shown in Figures 1 and 3). It follows that moving left from x^* along the frontier represents only a second-order loss in terms of the mean, but a first-order gain in terms of the CEO's expected utility due to the reduction in $\text{Var}(\hat{\theta})$. It follows, therefore, that the optimal contract would implement an action on the frontier of $\mathcal{X}$, but to the left of x^*; that is, the fact that the CEO's well-being is tied to how he is perceived creates a distortion away from expected-return maximization even under complete contracting.[20]

[20]This result complements one in Holmstrom and Ricart i Costa (1986), which found that the maximum expected return is also not attainable with contracting when the CEO's

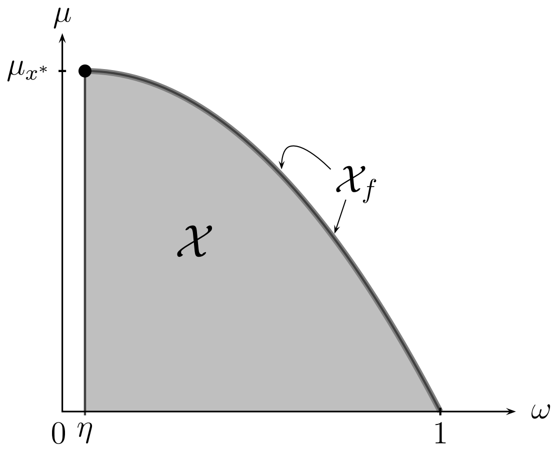

Figure 3: Situation in which complete disclosure maximizes expected return. (Under disclosure, the CEO chooses the indicated point on the top left corner of $\mathcal{X}$.)

Of course, it is not obvious that contracts can be contingent on actions. Actions could be difficult or costly to describe contractually, or their properties difficult to verify in case of dispute, or both. Consequently, it could well be that contracts are necessarily incomplete; even with complete disclosure, there are aspects of action choice that, although observable, are not verifiable. For instance, experts in the relevant area can look at an action *ex post* and determine its properties (*i.e.*, μ_x and h_x)—and therefore appropriately update their estimate of the CEO's ability—but the courts could lack that expertise or find it prohibitively expensive to acquire. Hence, in short, contracts contingent on action could be infeasible.

Regardless of disclosure regime, another possibility is contracts that are contingent on outcomes (*i.e.*, r). The feasibility of such contracting biases the owners toward a no-disclosure regime. The logic for this is as follows. Under complete disclosure, pushing the CEO toward a higher-mean, but less noisy action (higher ω) is costly to the owners insofar as they will have to com-

action is not disclosed (in their model contracts are contingent on performance—a topic we take up next).

pensate him more in expectation because he is bearing greater reputational risk. Under no disclosure, such a move *reduces* reputational risk in equilibrium. With no disclosure, the CEO's choice of action is correctly anticipated in equilibrium. Given that people know the CEO has an incentive contract based on returns, they will infer he will choose a higher-mean and noisier action than he would have absent an incentive contract. Consequently, the equilibrium action will prove to be one with a higher mean return, but more noise (*i.e.,* it will lie closer to x^*). Again, because no one is misled in equilibrium, $x = \hat{x}$; this means that inducing a higher-mean and noisier (lower $\omega_{\hat{x}}$) project in equilibrium raises the CEO's expected utility *ceteris paribus.*

A further factor that biases the owners toward a no-disclosure regime arises if the CEO is risk averse in compensation. In this case, a cost of using an incentive contract is compensating the CEO for making him bear risk. Because the CEO chooses an action that is noisier than x^* (to its left) under complete disclosure, but that is less noisy than x^* (to its right) under no disclosure, compensation risk is greater under a complete-disclosure regime than under a no-disclosure regime. This means the owners' cost of incentives is greater under a complete-disclosure regime than under a no-disclosure regime.

To summarize:

Proposition 9 *If the owners would prefer the CEO's choice of action not be disclosed were incentive contracting (a contract contingent on r) infeasible, then they prefer it not be disclosed when incentive contracting is feasible.*

IV Issues with the Current Model

There are undoubtedly concerns that one might have about the models considered so far. One is that, if information revelation is so costly, then why reveal it *publicly?* That is, would it not make more sense to have the information revealed only to the board of directors, who could then take appropriate action, without it being revealed publicly?

This argument is certainly one motive for keeping some information in the hands of management and directors only. But this doesn't contradict the model—indeed, the model is providing the very justification for secrecy on the part of the board. Moreover, the issues about the quality of information identified are still relevant; albeit the concern would then be the quality of internal information rather than public information. As with public information, CEOs would also have incentives to manipulate internal information transfers in order improve the board's perception of them; this idea has been explored extensively in recent work (see, *e.g.,* Adams and Ferreira, 2007).

In a number of publicized cases, boards have been kept in the dark except through their ability to access publicly disclosed documents. Hence, there could be downsides to keeping all relevant information within the firm.[21]

A key element in some of our analysis is that the CEO is risk averse with respect to the posterior estimate of their ability. This assumption is in line with the standard belief that economic actors are risk averse in income. Nevertheless, it is worth considering this assumption in greater detail. If the CEO's payoff were convex in the posterior estimate of his ability—as opposed to our maintained assumption of concave in the posterior estimate—then the consequence for our results would be as follows:

- For the model of Section I, both owners and the CEO would wish to maximize the precision of signal when the CEO's payoff is convex in the posterior estimate of his ability. The consequence of greater precision for the CEO's compensation could be ambiguous, however—there is no longer any need to compensate him for greater risk, but the increase in firm value could still lead to an increase in his compensation when he has a significant amount of bargaining power.

- The CEO still benefits from a higher signal, so he would still have an incentive to distort the signal upward. Hence, even with risk-loving managers, there would be a motive to limit the informativeness of the signal in order to reduce this potential agency problem.

- In Section III, there would still be an agency problem with respect to action with risk-loving managers. However, in this case, the CEO prefers the safest action when his action is disclosed. For the scenarios of Figures 1 and 2, the safest action would *not* maximize expected return. If action is not disclosed, then the CEO will prefer the riskiest action, *ceteris paribus.* Again, this action would not necessarily be the one that maximizes shareholders' welfare.

[21] As an anonymous referee notes, this begs the question of why the board lets the CEO conceal information from it. A partial answer is that, absent clear reporting requirements, the board may be unaware that information exists that it hasn't been shown.

It is possible that even if the CEO's underlying preferences are not risk-loving, that market-based incentives could be such that he effectively becomes so. For example, suppose there is a value of $\hat{\theta}$ such that the CEO's pay is 0 if his estimated ability is below that (he is fired and his career is over), but an increasing function of the estimate above that value (due to bidding for his services). As is well-known, such a "hockey stick" payoff function can induce a preference for risk for at least some parameter values.

Market-based incentives could also be such that the CEO is indifferent to risk. To see this, suppose the setting is tournament-like, or that a superstar effect exists. Suppose, for instance, that the CEO obtains a "prize" if he outperforms another, and that performance is totally a function of ability (*i.e.,* there is no scope for actions that distort the signal). Assume the competitors have the same expected ability, that ability is distributed normally, and that their performances are independent. A given competitor wins when his posterior estimate, $\hat{\theta}_1$, exceeds that of the other, $\hat{\theta}_0$; that is, when the random variable $\hat{\theta}_1 - \hat{\theta}_0 \geq 0$. Regardless of the variances of $\hat{\theta}_i$, $i = 0, 1$, the difference $\hat{\theta}_1 - \hat{\theta}_0$ is distributed normally with mean 0, which means that the probability of CEO 1 winning is one-half regardless of the variances of the normally distributed random variables. Consequently, he is indifferent to those variances. If, however, the size of the prize for winning was a function of the posterior estimate or a function of the difference in the posteriors, then risk would again matter to the CEOs.

We have assumed, recall, that the CEO has no better knowledge of his ability than those who hire him. Although, for the reasons discussed above, we consider this to be a reasonable assumption, it is worth discussing the alternative scenario in which he has superior information. Suppose, in this regard, that the CEO has received a private signal of his ability prior to his employment. In our base model, this has no consequence: Recall the owners set the disclosure regime *prior* to bargaining with the CEO over compensation. This change in assumptions would have consequence only if we simultaneously changed the model's timing to allow the shareholders to bargain with the CEO over both compensation *and* disclosure. In this case, a CEO with a higher private signal will presumably be more willing to trade off increased disclosure for greater compensation than a CEO who has received a lower private signal. But, in essence, we will arrive at the same result: A greater level of disclosure correlates to greater CEO compensation. Nor would such a change in assumption eliminate the agency problem that arises because the CEO has an incentive to choose actions that raise the value of future signals or distorts their informativeness.

With the exception of Section III.A, we have ignored the possible use of contracts between owners and the CEO to mitigate some of the tension between them. In particular, given the cost of better information is exposing the CEO to greater risk, one might naturally think of providing him insurance. Given the owners have been assumed to be risk neutral, efficiency dictates they bear all the risk—fully insure the CEO—*ceteris paribus*. Were the owners to do so, the consequence would be to eliminate any motive to have the signal be less than maximally informative. In a simple model, for instance when the owners are deciding between keeping or dismissing the incumbent CEO and $u(\cdot)$ is given by (6), then a golden parachute equal to the CEO's loss should he be dismissed is optimal and the owners should choose to make the signal maximally informative (see Proposition A.1 in the appendix).

On other hand, it seems unreasonable to predict that the owners would want to fully insure the CEO. After all, if they fully insure him, then they are in a position of paying him more the worse he performs (*i.e.,* low values of the signal are more rewarded than high values). This would create rather perverse incentives for the CEO; in particular, if there is any moral hazard at all, then full insurance would backfire on the owners. Just as moral hazard precludes full insurance in most settings (*e.g.,* automobiles, houses, etc.), it seems reasonable to imagine it precluding full insurance here.

In addition, one can conceive of situations in which the signal is observable, but not verifiable. For instance, suppose the signal reflects sensitive information, is difficult to quantify, or is difficult to describe *ex ante*. In such cases, it would be infeasible to base an insurance contract on it. Another reason the information could be private is that the agent in question is at a level at which public information is not released or is otherwise not available; he could be, for example, a plant manager and it is top management that is playing the owners' role.

V Implications for Empirical Work

We have presented a series of models suggesting that a firm's disclosure policy is fundamentally connected to its governance. Improved disclosure provides benefits, but it also entails costs. These costs are both direct, in terms of greater managerial compensation, and indirect, in terms of the distortions they induce in managerial behavior (*i.e.,* management's actions aimed at obfuscation).

This analysis has a number of implications for empirical analysis. First, consider a reform that increases the formal disclosure requirements—or any kind of exogenous change in the quantity of information that is available about a firm (*e.g.,* greater coverage of the firm in the news media). Our model predicts that, for those firms for which the reform is binding, we should observe (i) increases in their CEO's compensation; (ii) increases in their CEO's turnover rates; and (iii) a decreases in firm value. Certainly, there has been an enormous increase in interest in top management compensation and turnover in recent years; our model suggests that this interest plays somewhat of a self-fulfilling prophesy, leading to increased compensation and turnover in large U.S. corporations (see Huson et al., 2001, and Kaplan and Minton, 2008, for evidence on changes in turnover and compensation). In fact, this pattern holds not only in recent U.S. data: Bayer and Burhop (in press) finds that German bank executives became more vulnerable to dismissal after a major reform in 1884, which increased reporting requirements. In addition, Bayer and Burhop (2007) finds that executive compensation also increased following that 19th-century reform.

Another prediction of the model is that increases in information available about firms should be associated with an increase in actions aimed at obfuscation (a past example of such actions being, perhaps, Enron's use of special-purpose entities, which led to its financial statements being particularly uninformative). In addition to accounting-related actions, our model suggests that increased disclosure requirements leads to a change in real investments. This change in real investment decisions potentially manifests itself as an increase in myopic behavior, for instance substitution away from longer-term investments, such as R&D, toward shorter-term investments or actions that affect reported numbers sooner.[22]

A second category of empirical implications concerns cross-sectional comparisons of similarly regulated firms. Differing underlying structures of businesses can lead to essentially exogenous differences in disclosure and transparency. For example, the relatively transparent nature of information disclosure in the mutual-fund industry means more information is available about a mutual-fund manager than is available about managers in indus-

[22]See Stein (1989) for more discussion of such negative NPV investments due to managerial myopia, and Graham et. al (2005) for survey evidence suggesting that executives claim to engage in such myopic behavior.

tries where information is less clear cut and harder to assess. Our model suggests that in greater or more informative disclosure industries, managerial pay and turnover rates will be greater than in industries with less or less informative disclosure.

There should also be cross-sectional variation in firm activities across industries with different inherent levels of transparency. For instance, consider again a mutual-fund manager. His job, which is to pick securities whose identity is publicly available, is highly transparent. In contrast, a manager of a technology firm has a job that is fundamentally less transparent; his investments are harder to assess and often less visible. Proposition 7 suggests, all else equal, that in more transparent industries, managers should be more willing to undertake risky investments than in less transparent industries. In less transparent industries, observers are more likely to infer that the manager is low ability after witnessing poor performance.

Another potential test of our model is to consider (i) whether firms with more disclosure or higher quality disclosure pay their executives more; and (ii) whether executives at these firms have shorter tenures once other factors have been controlled for. The amount of disclosure (information revealed) could be measured, for instance, by the amount of press coverage a firm receives or the number of analysts following a firm. The quality of the information disclosed could be measured directly as was done, for instance, by the Financial Analysts Federation's Committee on Financial Reporting.[23] Another possible measure of the quality of reporting could be the precision of analysts' forecasts; the better the quality of reporting, the less variance there should be across the forecasts of different analysts.

VI Discussion and Conclusions

Corporate disclosure is widely seen as an unambiguous good. This paper, building on models of career concerns and managerial myopia, shows this view is, at best, incomplete. Disclosure can create or exacerbate agency problems and, thus, there can be an optimal limit on how much information or the quality of information disclosed.

The model and its variations presented above reflect fairly general or-

[23]See Lang and Lundholm (1993) or Shaw (2003) for examples of work using these measures of disclosure quality.

ganizational issues. A principal desires information that will improve her decision making (*e.g.,* whether or not to fire the agent, tender her shares, move capital from the firm, etc.). This information, however, has the potential to harm the agent either directly through career concerns or indirectly through the actions it leads the principal to take. The agent's compensation will reflect both this potential harm to him and the potential benefit to the principal. In addition, the agent may take undesired actions to mitigate the harm to him. Both these channels mean that better information is not an unambiguous good for the principal. In particular, she will need to balance these costs against her benefit from better information.

Although the analysis addresses a general organizational problem, its specific applicability varies depending on particular circumstances. By design, the analysis is meant to speak to various issues connected to corporate disclosure. However, by suitably changing the identity of the "owners" and the "ceo," the model can be thought of as focusing on the relationship between the board and ceo, with the signal representing information transmitted to the board. Alternatively, the "ceo" could represent the entire management team, and the "owners" the shareholders, or even the market as a whole. In this interpretation, the signal could be thought of as accounting or other information that is released publicly.

The model highlights the underlying relation between corporate governance and disclosure policy. *Ceteris paribus*, more information about management improves profit (*e.g.,* by allowing owners to make better decisions about retaining or dismissing management). But the situation is not *ceteris paribus*, because the information structure affects managers' well-being and, hence, their compensation and actions. In equilibrium, the profit-maximizing level of information can be less than full disclosure. Regulations that require disclosure beyond this level will reduce firm value.

Some issues remain. We have abstracted away from any of the concerns about revealing information to rivals or to regulators that other work has raised. We have also ignored other competing demands for better information, such as to help and better resolve the principal-agent problem through incentive contracts (see, *e.g.,* Grossman and Hart, 1983, and Singh, 2004). Finally, we have ignored the mechanics of how the firm actually makes information more or less informative; what accounting rules should be used, what organizational structures lead to more or less informative information, etc. While future attention to such details will, we believe, shed additional light on the subject, we remain confident that our general results will continue to hold.

Appendix A: Technical Details and Proofs

The following result is well-known, but worth stating and proving for completeness.

Lemma A.1 *Let $f(\cdot,\cdot):\mathbb{R}^2\to\mathbb{R}$ be a function at least twice differentiable in its arguments. Suppose that $f_{12}(\cdot,\cdot)>0$.*[24] *Let $\hat{x}$ maximize $f(x,z)$ and let $\hat{x}'$ maximize $f(x,z')$, where $z>z'$. Then $\hat{x}\geq\hat{x}'$. Moreover, if $\hat{x}'$ is an interior maximum, then $\hat{x}>\hat{x}'$.*

Proof: By the definition of an optimum (revealed preference):

$$f(\hat{x},z)\geq f(\hat{x}',z)\text{ and}\tag{27}$$

$$f(\hat{x}',z')\geq f(\hat{x},z')\,.\tag{28}$$

Expressions (27) and (28) imply

$$\begin{aligned}0&\leq\big(f(\hat{x},z)-f(\hat{x}',z)\big)-\big(f(\hat{x},z')-f(\hat{x}',z')\big)\\&=\int_{\hat{x}'}^{\hat{x}}\big(f_1(x,z)-f_1(x,z')\big)dx=\int_{\hat{x}'}^{\hat{x}}\left(\int_{z'}^{z}f_{12}(x,\zeta)d\zeta\right)dx\,,\end{aligned}$$

where the integrals follow from the fundamental theorem of calculus. The inner integral in the rightmost term is positive because $f_{12}(\cdot,\cdot)>0$ and the direction of integration is left to right. It follows that the direction of integration in the outer integral must be weakly left to right; that is, $\hat{x}'\leq\hat{x}$. To establish the moreover part, because $f_1(\cdot,\zeta)$ is a differentiable function for all ζ, if $\hat{x}'$ is an interior maximum, then it must satisfy the first-order condition

$$0=f_1(\hat{x}',z')\,.$$

Because $f_{12}(\cdot,\cdot)>0$ implies $f_1(\hat{x}',z)>f_1(\hat{x}',z')$, it follows that $\hat{x}'$ does not satisfy the necessary first-order condition for maximizing $f_1(x,z)$. Therefore

[24]Note the convention of using subscripts to denote partial derivatives (*i.e.*, f_i denotes the partial derivative with respect to the ith argument and f_{ij} denotes the partial derivative with respect to the ith and jth arguments).

$\hat{x}' \neq \hat{x}$; so, by the first half of the lemma, $\hat{x}' < \hat{x}$. ■

Proof of Lemma 1: Consider the "moreover" part first. The result follows from Lemma A.1 given

$$\frac{\partial^2}{\partial a \partial \hat{\theta}} \Big(\hat{\theta} v(a) - c(a) \Big) = v'(a) > 0 \,.$$

Consider the first part of the lemma. If $\mathcal{A} = \{0,1\}$, then

$$V(\hat{\theta}) = \begin{cases} -f \,, & \text{if } \hat{\theta} < -f \\ \hat{\theta} \,, & \text{if } \hat{\theta} \geq -f \end{cases} \,.$$

This is clearly a convex, but not affine, function. If $\mathcal{A}$ is an interval, then to show $V(\cdot)$ is convex we need to show that, for any $\hat{\theta}$ and $\hat{\theta}' \neq \hat{\theta}$,

$$V(\hat{\theta}') \geq V(\hat{\theta}) + V'(\hat{\theta})(\hat{\theta}' - \hat{\theta}) \tag{29}$$

and $V(\cdot)$ continuous. By the envelope theorem, $V'(\hat{\theta}) = v\big(a^*(\hat{\theta})\big)$. By revealed preference

$$\begin{aligned} V(\hat{\theta}') \geq \hat{\theta}' v\big(a^*(\hat{\theta})\big) - c\big(a^*(\hat{\theta})\big) &= \hat{\theta}' v\big(a^*(\hat{\theta})\big) - c\big(a^*(\hat{\theta})\big) + \Big(\hat{\theta} v\big(a^*(\hat{\theta})\big) - \hat{\theta} v\big(a^*(\hat{\theta})\big) \Big) \\ &= V(\hat{\theta}) + v\big(a^*(\hat{\theta})\big)(\hat{\theta}' - \hat{\theta}) = V(\hat{\theta}) + V'(\hat{\theta})(\hat{\theta}' - \hat{\theta}) \,. \end{aligned}$$

Hence (29) holds. From the moreover part of the lemma, if $a^*(\hat{\theta}) = a^*(\hat{\theta}')$, then $a^*(\cdot)$ is a constant on the interval between $\hat{\theta}$ and $\hat{\theta}'$. It follows that $V(\cdot)$ is continuous on this interval in that case. In light of this, the only other case we need consider is the one in which $a^*(\cdot)$ varies over the interval between $\hat{\theta}$ and $\hat{\theta}'$. But, given $v(\cdot)$ and $c(\cdot)$ are twice differentiable, and (3) is strictly quasi-concave, it follows that $V(\cdot)$ is continuous by the implicit function theorem. So $V(\cdot)$ is convex and we need, now, only establish it is not affine. To do so, we need to show there exists $\hat{\theta}$ and $\hat{\theta}'$ such that

$$V(\hat{\theta}') > V(\hat{\theta}) + V'(\hat{\theta})(\hat{\theta}' - \hat{\theta}) \,. \tag{30}$$

To this end, recall, by assumption, there exist $\hat{\theta}$ and $\hat{\theta}' \neq \hat{\theta}$ such that $a^*(\hat{\theta}) \neq a^*(\hat{\theta}')$. Because, by assumption, the maximum of (3) is unique, it follows for such a pair that

$$V(\hat{\theta}') > \hat{\theta}' v\big(a^*(\hat{\theta})\big) - c\big(a^*(\hat{\theta})\big) = V(\hat{\theta}) + V'(\hat{\theta})(\hat{\theta}' - \hat{\theta}) \,.$$

So (30) holds. ■

Proof of Proposition 3: We first consider the case for $\lambda \in (0,1)$. In light of Lemma A.1, it is sufficient to prove that the cross-partial derivative of (11) with respect to q and w is positive. Letting $\mathcal{V}(q) = \mathbb{E}\{V(\hat{\theta})|q\}$ and $\mathcal{U}(q) = \mathbb{E}\{u(\hat{\theta})|q\}$, calculations reveal that cross-partial derivative to be:

$$\frac{\lambda \mathcal{V}'(q)}{\big(\mathcal{V}(q) - w\big)^2} - \frac{(1-\lambda)\mathcal{U}'(q)y'(w)}{\big(\mathcal{U}(q) + y(w) - \bar{u}\big)^2} > 0\,,$$

where the sign follows because $\mathcal{V}'(q) > 0$ by Proposition 1, $\mathcal{U}'(q) < 0$ by Proposition 2, and $y'(w) > 0$ by assumption.

If $\lambda = 1$ (*i.e.,* owners have all the bargaining power), then the CEO's participation constraint,

$$\mathcal{U}(q) + y(w) \geq \bar{u}\,, \tag{31}$$

either binds or is slack if it holds at $w = 0$. When it is slack the result is obvious (w can go in only one direction). When it binds, an increase in q lowers $\mathcal{U}(q)$, which must be offset by an increase in w to maintain (31) as an equality.

If $\lambda = 0$ (*i.e.,* the CEO has all the bargaining power), then the owners' participation constraint,

$$\mathcal{V}(q) - w \geq 0\,, \tag{32}$$

binds. Because an increase in q raises $\mathcal{V}(q)$, it must be offset by an increase in w to maintain (32) as an equality. ■

Proof of Proposition 4: As in the proof of Proposition 3, define $\mathcal{V}(q) = \mathbb{E}\{V(\hat{\theta})|q\}$ and $\mathcal{U}(q) = \mathbb{E}\{u(\hat{\theta})|q\}$.

Because of bargaining, the CEO's compensation is a function of firm size, M, and precision of information, q. Write it as $w(q, M)$. The firm's owners choose q to maximize

$$M\mathcal{V}(q) - w(q, M)\,. \tag{33}$$

From Lemma A.1 and earlier results, the proposition follows if the cross-partial derivative of (33) with respect to M and q is positive; that is,

$$V'(q) - \frac{\partial w(q, M)}{\partial q \partial M} > 0\,. \tag{34}$$

We need, therefore, to establish (34). To that end, rewrite (15) as

$$0 = -\Lambda\Big(\mathcal{U}(q) + y\big(w(q,M)\big)\Big) + \big(M\mathcal{V}(q) - w(q,M)\big)y'\big(w(q,m)\big)\,.$$

This is an identity, so we can differentiate it with respect to M. Doing so and rearranging, we have

$$\Big((1+\Lambda)y'\big(w(q,m)\big)-\big(M\mathcal{V}(q)-w(q,M)\big)y''\big(w(q,m)\big)\Big)\frac{\partial w}{\partial M} = \mathcal{V}(q)y'\big(w(q,m)\big)$$

Dividing through by $y'\big(w(q,m)\big)$ we have

$$\left((1+\Lambda) - \big(M\mathcal{V}(q) - w(q,M)\big)\frac{y''\big(w(q,m)\big)}{y'\big(w(q,m)\big)}\right)\frac{\partial w}{\partial M} = \mathcal{V}(q)\,. \tag{35}$$

Observe, first, that if marginal utility is constant, $y''(\cdot) \equiv 0$. In this case, (35) becomes

$$(1+\Lambda)\frac{\partial w}{\partial M} = \mathcal{V}(q)\,.$$

Because $\Lambda > 0$, it follows that (34) holds.

Suppose, instead, that $y'(\cdot)$ is log concave. This implies that $y''(w)/y'(w)$ is a decreasing function of w. Recalling that q maximizes (33), we can differentiate (35) with respect to q to yield:

$$\underbrace{\left((1+\Lambda) - \big(M\mathcal{V}(q) - w(q,M)\big)\frac{y''\big(w(q,m)\big)}{y'\big(w(q,m)\big)}\right)}_{>1}\frac{\partial^2 w}{\partial q\partial M}$$
$$- \underbrace{\big(M\mathcal{V}(q) - w(q,M)\big)}_{(+)}\underbrace{\frac{d}{dw}\left(\frac{y''\big(w(q,m)\big)}{y'\big(w(q,m)\big)}\right)}_{(-)}\underbrace{\frac{\partial w}{\partial q}}_{(+)} = V'(q)\,,$$

where the sign of $\partial w/\partial q$ follows from Proposition 3. Expression (34) follows. ■

Lemma A.2 *Given that $u(\cdot)$ is $\mathcal{L}^2$ for any normal distribution, it follows that $u'(\cdot)$ is $\mathcal{L}$ for any normal distribution; that is, that $\mathbb{E}\{u'(z)\}$ exists (is finite) if z is distributed normally.*

Proof: We wish to show that $d\mathbb{E}\{u(\lambda z)\}/d\lambda$ is finite evaluated at $\lambda = 1$. Observe

$$\mathbb{E}\{u(\lambda z)\} \equiv \int_{-\infty}^{\infty} u(\lambda z)\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{1}{2\sigma^2}(z-\mu)^2}dz \equiv \int_{-\infty}^{\infty} u(\zeta)\frac{1}{\lambda\sigma\sqrt{2\pi}}e^{-\frac{1}{2(\lambda\sigma)^2}(\zeta-\lambda\mu)^2}d\zeta\,.$$

Hence,

$$\begin{aligned}\frac{d\mathbb{E}\{u(\lambda z)\}}{d\lambda} &= -\frac{1}{\lambda}\int_{-\infty}^{\infty} u(\zeta)\frac{1}{\lambda\sigma\sqrt{2\pi}}e^{-\frac{1}{2(\lambda\sigma)^2}(\zeta-\lambda\mu)^2}d\zeta \\ &\qquad + \frac{1}{\lambda^3\sigma^2}\int_{-\infty}^{\infty} u(\zeta)\zeta(\zeta-\lambda\mu)\frac{1}{\lambda\sigma\sqrt{2\pi}}e^{-\frac{1}{2(\lambda\sigma)^2}(\zeta-\lambda\mu)^2}d\zeta\,.\end{aligned}$$

The first integral is finite because $u(\cdot)$ is such that expected utility exists for all normal distributions. The second integral is the expectation of the product of two $\mathcal{L}^2$ functions with respect to normal distributions, $u(\zeta)$ and $\zeta(\zeta-\lambda\mu)$, and thus it is also integrable with respect to a normal distribution (see, *e.g.,* Theorem 10.35 of Rudin, 1964). Since both integrals are finite, their sum is finite. Hence, $d\mathbb{E}\{u(\lambda z)\}/d\lambda$ is everywhere defined, including at $\lambda = 1$. ■

Proof of Proposition 5: For both parts of the proposition, because $d(\cdot)$ is convex, x_E is increasing if the integral in (19) is increasing in the relevant variable and decreasing if the integral is decreasing in the relevant variable. In what follows, let $R(\cdot)$ denote the coefficient of absolute risk aversion; that is, $R(\eta) = -u''(\eta)/u'(\eta)$.

Recall that an increase in q reduces the variance of the signal ($d\,\mathrm{Var}(s)/dq = -1/q^2$). Hence, to prove (i) it is sufficient to shown that the integral in (19) is decreasing in $\mathrm{Var}(s)$ or, equivalently, decreasing in $\sqrt{\mathrm{Var}(s)} \equiv \sigma$.

Differentiating the integral in (19) with respect to σ yields

$$-\frac{1}{\tau\sigma^3}\int_{-\infty}^{\infty}\left(2u'\Big(\frac{z}{\tau\sigma}\Big)+\frac{z}{\tau\sigma}u''\Big(\frac{z}{\tau\sigma}\Big)\right)\phi(z)dz\,. \tag{36}$$

Expression (36) will be negative, proving part (i) of the proposition, if

$$\int_{-\infty}^{\infty} u'\Big(\frac{z}{\tau\sigma}\Big)\left(2-\frac{z}{\tau\sigma}R\Big(\frac{z}{\tau\sigma}\Big)\right)\phi(z)dz \tag{37}$$

is positive. Rewrite (37) as

$$2\int_{-\infty}^{\infty} u'\Big(\frac{z}{\tau\sigma}\Big)dz - \frac{1}{\tau\sigma}\int_{-\infty}^{\infty} u'\Big(\frac{z}{\tau\sigma}\Big)R\Big(\frac{z}{\tau\sigma}\Big)\,z\,dz \tag{38}$$

The first integral is positive because $u'(\cdot) > 0$. The second integral in (38) is the covariance of $u'\left(\frac{z}{\tau\sigma}\right)R\left(\frac{z}{\tau\sigma}\right) \equiv G(z)$ and z. $G(\cdot)$ is a non-increasing function, so the covariance is non-positive.[25] Hence, the second integral in (38) is non-positive, making (38) itself positive. We have, thus, proved part (i) of the proposition.

Differentiating the integral in (19) with respect to τ yields

$$-\frac{1}{\tau^2}\int_{-\infty}^{\infty} u'\left(\frac{z}{\tau\sigma}\right)\left(\frac{1}{\sigma^2} - \frac{z}{\sigma}R\left(\frac{z}{\tau\sigma}\right)\right) dz\,.$$

The same type of argument as used above establishes the last expression is negative, which thereby establishes part (ii) of the proposition. ■

Proof of Lemma 4: Suppose, in equilibrium, the CEO chose not to choose an $(\omega, \mu) \in \mathcal{X}_f$. Let $(\omega_{\hat{x}}, \mu_{\hat{x}})$ be his choice. By supposition, either $\mu_{\hat{x}} < M(\omega_{\hat{x}})$ or $\omega_{\hat{x}} < \Omega(\mu_{\hat{x}})$ or both. Suppose, first, that it is the former. Then there exists $(\omega_{\hat{x}}, \mu^*) \in \mathcal{X}$ such that $\mu^* > \mu_{\hat{x}}$. It is readily shown that an increase in the mean of a normal random variable, holding variance constant, constitutes an improvement in the distribution in the sense of first-order stochastic dominance. Given the CEO's utility is an increasing function of $\hat{\theta}$, it follows from (26′) that the CEO would do better to deviate to $(\omega_{\hat{x}}, \mu)$. But if the CEO wishes to deviate, then we're not in equilibrium, a contradiction.

Suppose, instead, $\omega_{\hat{x}} < \Omega(\mu_{\hat{x}})$. Then there exists $(\omega^*, \mu_{\hat{x}}) \in \mathcal{X}$ such that $\omega^* > \omega_{\hat{x}}$. A decrease in the variance of a normal random variable, holding mean constant, constitutes an improvement in the distribution in the sense of second-order stochastic dominance. Given the CEO's utility is concave in $\hat{\theta}$, to follows from (26′) that the CEO would do better to deviate to $(\omega^*, \mu_{\hat{x}})$. But if the CEO wishes to deviate, then we're not in equilibrium, a contradiction.

The result follows *reductio ad absurdum.* ■

Proposition A.1 *Consider the model of Section I. Suppose the (expected) payoff to the owners if they retain the incumbent* CEO *equals his ability and their payoff if they fire him is $-f - g$, where $f > 0$ is a firing cost and $g \geq 0$ is a golden parachute. Assume the* CEO*'s utility is given by (6); that is, he loses ℓ if fired. Finally, suppose the owners possess all the bargaining power. Then the optimal golden parachute equals ℓ and the optimal precision of the signal is maximal.*

[25] Recall that $\mathbb{E}\{z\} = 0$, so $\mathbb{E}\{z\,G(z)\}$ is the covariance of z and $G(z)$.

Proof: Observe

$$V(\hat{\theta}) = \begin{cases} -f-g\,, & \text{if } \hat{\theta} < -f-g \\ \hat{\theta}\,, & \text{if } \hat{\theta} \geq -f-g \end{cases} .$$

Hence,

$$\begin{aligned}\mathbb{E}\{V(\hat{\theta})\} &= -\Phi\left(\frac{-f-g}{\sigma}\right)(f+g) + \int_{-f-g}^{\infty} \frac{\hat{\theta}}{\sigma\sqrt{2\pi}}\phi\left(\frac{\hat{\theta}}{\sigma}\right) d\hat{\theta} \\ &= -\Phi\left(\frac{-f-g}{\sigma}\right)(f+g) + \sigma\phi\left(\frac{-f-g}{\sigma}\right), \qquad (39)\end{aligned}$$

where $\sigma = \sqrt{\text{Var}(\hat{\theta})}$.

The CEO's expected utility is

$$(g-\ell)\Phi\left(\frac{-f-g}{\sigma}\right) + w\,, \qquad (40)$$

where w is his non-contingent compensation. For the CEO to be willing to accept employment (40) cannot be less than the CEO's reservation utility, $\bar{u}$. Because w is a pure expense, the owners optimally set it as low as possible, hence the participation constraint is binding. The owners' expected profit is, therefore,

$$-\Phi\left(\frac{-f-g}{\sigma}\right)(f+\ell) + \sigma\phi\left(\frac{-f-g}{\sigma}\right) - \bar{u}\,.$$

The first-order conditions with respect to g and σ are, respectively,

$$\frac{1}{\sigma}\phi\left(\frac{-f-g}{\sigma}\right)(f+\ell) - \frac{1}{\sigma}\phi\left(\frac{-f-g}{\sigma}\right)(f+g) = 0 \quad \text{and} \qquad (41)$$

$$\left(1 + \frac{(f+g)^2}{\sigma^2} - \frac{(f+g)(f+\ell)}{\sigma^2}\right)\phi\left(\frac{-f-g}{\sigma}\right) > 0 \qquad (42)$$

Clearly, the only solution to (41) is $g = \ell$. Given that solution, the left-hand side of (42) becomes ϕ, verifying the indicated inequality. Because σ is monotone in q, this implies that the optimal q is the largest possible q. ■

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