The Many Dials of Corporate Governance

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Abstract

Firms typically have many options to choose from when setting their overall governance structure. We study the relations between four such choices: board monitoring, board expertise, equity incentives, and information acquisition. In our equilibrium model, equity incentives are positively related to managerial information acquisition and negatively related to board expertise. Unlike the existing literature that views board monitoring and equity incentives as substitutes, we show that equity incentives and monitoring can also be complements. Our analysis highlights how examining the complex interactions among multiple governance choices can improve our understanding of efficient governance.

1 Introduction

Corporate governance plays a central role in modern corporations, aligning the actions of managers with the interests of shareholders. A myriad of studies examine the value implications of individual governance mechanisms, such as board structure, shareholder rights, executive compensation, and financial transparency. However, surprisingly little is known about how different governance mechanisms work together and possible complementary or substitutive effects across them.

In this paper, we develop a theoretical model to understand the equilibrium relations among four key governance mechanisms: board monitoring, board expertise, information acquisition, and managerial equity incentives. Specifically, we use a standard contracting model, but in addition to moral hazard, the manager also has limited information and can benefit from the board's expertise. To acquire information from the board, the manager needs to disclose some of her own information, which enables the board's advising, but also allows the board to more effectively monitor the manager. We derive optimal pay-for-performance and board structure in this environment, with managerial decisions being endogenous to communications between the board and the manager.

In our model, a manager is tasked with making a decision about whether or not to undertake an investment project. The project policy that maximizes firm value is one where the manager takes the project if and only if the state of the world is good. Managers may fail to maximize firm value either because their incentives are misaligned (they obtain private benefits from taking the project), or because they have limited information about the state of the world. The optimal corporate governance structure simultaneously (i) reduces the weight that the manager places on private benefits, and (ii) increases the information available to the manager.

The board performs both monitoring and advising functions in the model. Monitoring reduces the manager's private benefits from taking the project, while advising allows the board to use its expertise to inform the manager about which action may be appropriate (yield higher firm value). The manager's voluntary disclosure of information to the board is essential for the board to be an effective monitor or advisor. Equity incentives play two roles in our environment. First, they motivate the manager to care more about making the right decision, instead of simply choosing to take the project for its private benefits. Second, they motivate the manager to be more willing to disclose information to the board, which the board can then use to be an effective monitor and provide advice on the action that is likely to increase firm value. However, equity incentives are costly because they reduce the firm's share of the project's payout.

The equilibrium of the model predicts that equity incentives and board monitoring are *positively* related provided that board expertise exceeds some threshold. When board expertise is high, the firm would especially like the manager to share information with the board, so that the board can utilize its expertise to advise the manager. However, the manager may not want to share information because doing so also allows the board to become a more effective monitor. Equity incentives can be a mechanism to overcome this friction, so that the manager is willing to share information with the board.

The model also predicts that equity incentives are negatively related to board expertise provided that board expertise exceeds some threshold. There are two reasons for this. First, when board expertise is high, the manager is more willing to forego the loss in private benefits for the board's advice, which reduces the need to use equity incentives to incentivize the manager to share information with the board. Second, high board expertise increases the likelihood that the manager will be informed about the state of the world. When the manager is informed, she is more likely to make the decision that maximizes firm value rather than the one that yields private benefits, so less equity incentives are needed to resolve the incentive misalignment problem.

A key theoretical insight from our analysis is that equity incentives encourage managers to acquire additional information (here, from the board). This idea can potentially help explain empirical relations between equity incentives and a number of corporate disclosure variables. For instance, our model predicts that management forecast errors, a proxy for manager's information set, are negatively associated with equity incentives. Moreover, prior studies have documented a positive relation between equity incentives and corporate transparency (e.g., Nagar et al., 2003), but there does not appear to be a convincing explanation for the association. Our model predicts that equity incentives encourage the manager to share information with the board, which results in both parties having more information. This increase in managerial and board information then manifests in greater external reporting (Verrecchia, 1990).

This paper is related to the literature on equity incentives and pay-for-performance (e.g., Core et al., 2003; Edmans and Gabaix, 2016; Lambert, 2001). However, few existing studies examine how equity incentives should be designed to improve the information available to managers. Lin et al. (2018) build a model to examine how equity incentives affect the information that managers learn from stock price. Our model complements their analysis, but our focus is on how equity incentives motivate the manager to share information with and seek advice from the board, benefiting from the board's expertise.

Our paper also contributes to the corporate governance literature. There is a growing body of theoretical models on board structure. For instance, Adams and Ferreira (2007), Baldenius et al. (2014), and Tian (2014) examine the design of board monitoring when the board also relies on information from the CEO. Baldenius et al. (209), Kumar and Sivaramakrishnan (2008), and Laux and Mittendorf (2011) focus on the design of board structure when the board's incentives may not be completely aligned with shareholder's. Furthermore, Almazan and Suarez (2003) and Laux (2008) examine board monitoring and CEO turnover. Our contribution is to derive equilibrium relations between board monitoring, board expertise, equity incentives, and information acquisition, and in doing so, shed light on their interactions and spillover effects. Moreover, the existing literature primarily views incentive compensation and board monitoring as substitutes (e.g., Cai et al., 2015; Ferreira et al., 2011). Our model shows that in the presence of a board that monitors and advises, equity incentives play an additional role in motivating the manager to share information with the board, and as a result, equity incentives and board monitoring may be complements.

Finally, this paper is also related to the disclosure literature. In particular, several studies examine the feedback effects of voluntary disclosure. Dye and Sridhar (2002) build a model where firms may disclose a proposed strategy and implement that strategy only if the price reaction to the disclosure is sufficiently favorable. Luo (2005) empirically examines how the market reaction to an M&A announcement affects the likelihood that the deal is completed. Our contribution is to examine a setting where disclosure to the board, as opposed to the market, provides the manager with additional information.

The remaining of the paper proceeds as follows. Section 2 presents the model. Section 3 derives some preliminary results that illustrate the economic forces in the model. Section 4 derives the relations between various governance mechanisms in equilibrium. Section 5 discusses some model extensions that relax certain assumptions. Section 6 highlights the empirical implications. Section 7 concludes.

2 Model

A risk-neutral manager is hired by the firm to decide whether or not to undertake an investment project. The manager's project policy is $I = 1$ if the manager takes the project and $I = 0$ if she does not. The project's payout, V, depends on the state of the world S, which is either good or bad, $S \in \{G, B\}$. When the state is good, $V = 1$ if the project is taken and $V = 0$ if the project is not. On the other hand, when the state is bad, $V = 0$ if the project is taken and $V = 1$ if it is not.[1] That is,

$$V = \begin{cases} 1 & \text{if } S = G \text{ and } I = 1 \text{ or } S = B \text{ and } I = 0 \\ 0 & \text{if } S = G \text{ and } I = 0 \text{ or } S = B \text{ and } I = 1 \end{cases}. \tag{1}$$

There are two random variables that determine whether the state is good or bad, x and y. The state of the world is good when $x + y \geq 1$, and the state of the world is bad when $x + y < 1$. x and y are both uniformly distributed on $[0, 1]$. The manager privately learns the value of x.

The board has expertise but also requires the cooperation from the manager to utilize

[1] We may consider not taking the project as the action of choosing an alternative investment opportunity. For example, the project is a domestic investment, whereas the alternative is an international investment; the payoffs of the domestic versus international investments depend on the state of the world. While we restrict the manager's project policy to be binary, our main results generalize to situations where the manager can choose a continuous project policy (e.g., invest a fraction in the domestic project and the remaining fraction in the international project), due to the linearity of the manager's objective function.

its expertise. Cooperation here means that the manager will disclose all relevant information that she possesses, and for convenience, we assume that this information is simply the value of x. If the manager discloses x, the board will learn or fail to learn the value of y with probability $\lambda \in (0, 1)$ and $1 - \lambda$, respectively. We may consider λ as a measure of the board's expertise, with a higher λ indicating higher expertise.[2] If the manager does not disclose x to the board, the board does not learn y.

The board also monitors the manager. Monitoring is more effective when the board receives information (about x) from the manager. When the board receives no information from the manager, monitoring effectiveness is normalized to 0. When the board receives information about x, it can punish the manager if the manager does not follow the first-best project policy (defined in the next section).[3] Formally, a *strong* and *weak* board imposes penalty δ and 0, respectively, when the manager deviates from the first-best project policy.[4]

The manager's and firm's incentives can be misaligned because the manager obtains private benefits from taking the project. Specifically, when $I = 1$, she obtains private benefits $\delta > 0$, while if $I = 0$, her private benefits are 0. These private benefits can be interpreted in many ways, such as empire-building incentives, perquisites (e.g., a private jet, golf, country-club memberships, flexible work schedule) that come from the project. Private benefits in our model have no direct cost to the firm other than possibly distorting the manager's project policy.

The manager can choose either to disclose her private signal x to the board or not to disclose, denoted as $D = 1$ and $D = 0$, respectively. If she does, then the board learns y with probability λ, in which case it then decides either to communicate y to the manager or not to communicate y. We assume that if the board chooses to communicate y to the manager, it cannot misreport y. If the board communicates y, then the manager can use this information for her project policy. We denote the case where the board

[2] For our purposes, we treat λ as an exogenous parameter and focus on how its value matters for the design of corporate governance mechanisms.

[3] One way to interpret this "punishment" is that the board takes control of project selection and decides on the project instead of the manager.

[4] In Section 5, we relax the assumption that monitoring is binary to examine the extent to which our results extend to the case where monitoring is continuous.

communicates y to the manager as $A = 1$ and the case where the board does not as $A = 0$. Note that when the board does not communicate y to the manager, it could be because either it does not learn y or it chooses not to communicate y.

The firm can offer the manager equity incentives in the form of a fixed share $\beta \in [0, 1]$ of the project's terminal value V.[5] Thus, the manager's equity compensation is

$$\beta E[V] = \begin{cases} \beta & \text{if } S = G \text{ and } I = 1 \text{ or } S = B \text{ and } I = 0 \\ 0 & \text{if } S = G \text{ and } I = 0 \text{ or } S = B \text{ and } I = 1 \end{cases}.$$

The board cares about the value of the firm, which is the expected value of the project's return minus the cost of providing equity incentives. Specifically, the board's payoff, or expected firm value, is

$$(1 - \beta)E[V]. \tag{2}$$

The manager cares about both her expected compensation and her private benefits from taking the project. Her payoff is

$$\beta E[V] + \delta I. \tag{3}$$

where recall $I \in \{0, 1\}$ is the project policy and δ is the manager's private benefits from taking the project.

The timing of the game is as follows. The board first decides on the level of equity incentives β. The manager then decides on a disclosure policy after observing the level of equity incentives and her private information x. If the manager discloses x, then the board learns about y with probability λ. If the board successfully learns y, then the board decides whether or not to advise the manager about y. Given the level of equity incentives, her private information about x, and potentially information obtained from the board, the manager decides on a project policy. The state of the world S is then

[5] We assume in our main analysis that the equity incentives cannot depend on the manager's disclosure decision. This makes the firm's problem non-trivial and can be motivated by the observation that equity incentives are typically not contingent on disclosure by managers. Adams and Ferreira (2007) maintain a similar assumption in their model and argue that "due to the limited time they spend in the firm, directors may not know what information they need, which makes it difficult for them to implement such contracts" (pg. 223). Nonetheless, in Section 5, we discuss an extension that allows for equity incentives to depend on the manager's disclosure.

realized and so are payoffs.

A strategy of the board consists of a level of equity incentives β and an advising strategy Y with $Y : \{y, \emptyset\} \rightarrow \{y, \emptyset\}$. A strategy of the manager is a disclosure policy (D) and project policy (I), with $D : \{\beta, x\} \rightarrow \{0, 1\}$ and $I : \{\beta, x, D, Y\} \rightarrow \{0, 1\}$. A belief of the manager is about y, denoted as B_y. A belief of the board is about the manager's information x, denoted as B_x.

A Perfect Bayesian Equilibrium of this game consists of (i) the board's strategy that maximizes its payoff, given the manager's strategy and the board's belief; (ii) the manager's strategy that maximizes her payoff given her belief and the board's strategy. Moreover, both the manager's and the board's beliefs are consistent with their strategies and are updated according to Bayes' rule whenever possible. Each player correctly anticipates each other player's strategies in equilibrium.

3 Preliminaries

In this section, we derive some preliminary results about the first-best project policy, the manager's disclosure choice, and the expected project return given equity incentives. The results help illustrate the economic forces in our model, and they will be useful when we establish the equilibrium in the next section.

We start by deriving the first-best project policy in our model to serve as a benchmark. The first-best project policy is defined as the policy that the manager would take if her incentives were perfectly aligned with the firm's (i.e., private benefits are zero), so that the *ex-ante* expected return from the project, $E[V]$, is maximized.

Lemma 1: The first-best project policy is twofold. When the manager has information about x and y, she should take the project if and only if $x + y \geq 1$. When the manager only has information about x, she should take the project if and only if $x \geq q^{FB}$ where

$$q^{FB} = \frac{1}{2}. \tag{4}$$

Proof. When $x+y > 1$, the expected return from taking the project is $E[V|I = 1, x+y \geq 1] = 1$, while the expected return from not taking the project is $E[V|I = 0, x+y \geq 1] = 0$, so $I = 1$ is optimal when $x + y \geq 1$. When $x + y < 1$, the expected return from taking the project is $E[V|I = 1, x + y < 1] = 0$, while the expected return from not taking the project is $E[V|I = 0, x + y < 1] = 1$, so $I = 0$ is optimal when $x + y < 1$.

When $A = 0$, the manager estimates that the state is good with probability

$$P(x + y \geq 1|x) = 1 - P(x + y < 1|x) = 1 - P(y < 1 - x|x) = x.$$

Therefore, the expected project payout when $I = 1$ is $E[V] = x \cdot 1 + (1 - x) \cdot 0 = x$, and the expected project payout when $I = 0$ is $E[V] = x \cdot 0 + (1 - x) \cdot 1 = 1 - x$. It is thus optimal for $I = 1$ when $x \geq 1 - x \iff x \geq \frac{1}{2}$. ■

When the manager has information about both x and y, it is clear what policy would maximize the project return. However, when the manager only has information about x, the first-best project policy entails that the manager form an expectation about y and use this value to forecast the state of the world. Of course, the actual realization of y may differ from the expectation, leading to inefficient *ex-post* project selection, but nonetheless the first-best project policy maximizes *ex-ante* project payout.

Next, we derive the level of equity incentives needed to motivate the manager to take the first-best project policy when the manager receives information from the board. The role of equity incentives here is to motivate the manager to not take the project when the board's signal is unfavorable (i.e., $x + y < 1$). The manager obtains private benefits from taking the project, so she already has incentives to take the project when the board's signal is favorable (i.e., $x + y \geq 1$). Throughout the paper, we make the assumption that private benefits are lower than the project's potential payout.

Assumption 1: $\delta < 1$.

Lemma 2: Assume that the manager receives information about y from the board.

When the board is strong, $\beta = 0$ motivates the manager to take the first-best project policy. When the board is weak, $\beta = \delta$ motivates the first-best project policy.

Proof. When the board is strong and knows x, the manager will not receive private benefits if she deviates from the first-best project policy. Therefore, she will always take the action that maximizes $E[V]$ when $\beta = 0$.

Now consider the case when the board is weak, so that the manager can receive private benefits from taking the project even when it is not in the best interest of the firm. When the signal from the board is favorable (i.e., $x + y \geq 1$), the manager's expected payoff from $I = 1$ is $\beta + \delta > 0$, where 0 is the manager's payoff from $I = 0$. Hence, the manager always chooses $I = 1$. When the signal from the board is unfavorable (i.e., $x + y < 1$), the manager's expected payoff from $I = 1$ is δ, while her expected payoff from $I = 0$ is β. Then, $\beta = \delta$ motivates the manager not to take the project, which is the first-best policy in this case. ■

From Lemma 2, we see that monitoring and equity incentives are substitutes: lower equity incentives are needed to motivate the manager to take the first-best project policy for strong boards than for weak boards. However, this is not an equilibrium result, but rather assumes that the manager always receives information from the board. We will show that monitoring and equity incentives are no longer substitutes in equilibrium, when it is not a given that the manager will be perfectly informed.

Next, suppose that the manager does not receive information about y. There are three cases to consider:

(i) The board is strong and the manager discloses x to the board, but the board does not learn y.

(ii) The board is weak and the manager discloses x to the board, but the board does not learn y.

(iii) The manager does not disclose x to the board, and hence the board does not learn y.[6]

Lemma 3: Suppose that the manager does not receive information about y from the board. In case (i), $\beta = 0$ motivates the first-best project policy. In cases (ii) and (iii), there exists no β that can motivate the manager to take the first-best project policy (q^{FB}). Moreover, the manager will choose $I = 1$ if and only if $x \geq q_\beta$ where

$$q_\beta = \frac{1}{2} - \frac{\delta}{2\beta}. \tag{5}$$

Proof. In case (i), the board is strong and monitors the manager, so the manager will not receive private benefits by deviating from the first-best project policy. Therefore, she will always take the action that maximizes $E[V]$.

Now consider cases (ii) and (iii). If $I = 1$, the manager's payoff is

$$\beta E[V] + \delta = \beta(x + (1-x)\cdot 0) + \delta = \beta x + \delta,$$

while if $I = 0$, her payoff is $\beta E[V] = \beta(x \cdot 0 + (1-x)) = \beta(1-x)$. Therefore, the manager will optimally choose $I = 1$ if and only if

$$\beta x + \delta \geq \beta(1-x) \iff x \geq \frac{1}{2} - \frac{\delta}{2\beta}.$$

Let $q_\beta \equiv \frac{1}{2} - \frac{\delta}{2\beta}$. However, for any $\beta \geq 0$, the threshold (q_β) at which the manager chooses to take the project is too low relative to the first-best threshold ($q^{FB} = \frac{1}{2}$). ■

There is a distortion in the project policy that arises in cases (ii) and (iii). The manager may choose to take the project when the expected return would be higher if she did not. Increasing β reduces this distortion but cannot fully eliminate it. This illustrates

[6] One can easily verify that the board will always communicate y to the manager if it learns y. Hence, we have not included the case where the board learns y but does not communicate it to the manager.

one role of equity incentives in the model: to reduce distortions in the project policy due to the manager's private benefits. An important implication from (5) is that there is a one-to-one correspondence between β and the manager's project policy (q_β).

Also, monitoring and equity incentives continue to be substitutes here. When the board is strong (case (i)), no equity incentives are needed to motivate the first-best project policy ($\beta = 0$), while when the board is weak (case (ii)), higher β is potentially needed, even though no positive β can motivate the first-best project policy.

An additional insight from comparing Lemmas 2 and 3 is that information from the board can alleviate the agency problem: with the board's information the first-best project policy is obtained when $\beta = 0$ for the strong board and $\beta = \delta$ for the weak board; while without the board's information, the first-best project policy is never obtained ($q_\beta < q^{FB}$) when the board is weak.

We now derive the manager's optimal strategy on whether or not to disclose information to the board given the level of equity incentives and her private information x.

Proposition 1 (Disclosure Policy):

(i) Suppose the board is weak. It is optimal for the manager to choose $D = 1$.

(ii) Suppose the board is strong. It is optimal for the manager to choose $D = 1$ if one of the following three conditions is satisfied:

(a) $x < q_\beta$,

(b) $\beta \geq \delta$ and $x \geq q^{FB}$, or

(c) $\beta \geq \delta$ and $q_\beta \leq x \leq \tau$, where

$$\tau = \frac{\beta - \delta}{\beta(2-\lambda) - \lambda\delta}; \qquad q_\beta < \tau < 1; \qquad \frac{\partial \tau}{\partial \beta} > 0, \; \frac{\partial \tau}{\partial \lambda} \geq 0. \tag{6}$$

Otherwise, the manager optimally chooses $D = 0$.

Proof. (i) Suppose the board is weak. Then, the manager will not receive any penalty if $D = 1$, even when she makes the wrong decision using x. Hence, $D = 1$ for all x.

(ii) Now consider the case of a strong board. (a) If $x < q_\beta$, then, $I = 0$ from Lemma 3. Hence, the manager obtains positive payoff only when $S = B$, which occurs with probability $1 - x$. Therefore, the manager's expected payoff from $D = 0$ is $(1 - x)\beta$. On the other hand, if $D = 1$, the manager receives information about y from the board with probability λ and does not with probability $1 - \lambda$. Using Lemma 2, her payoff from knowing $x + y \geq 1$ is $\beta + \delta$, from knowing $x + y < 1$ is β, and using Lemma 3, her expected payoff when not receiving information about y from the board is $(1 - x)\beta$. Therefore, the manager's *ex-ante* expected payoff from choosing $D = 1$ is

$$\lambda x(\beta + \delta) + (1 - x)\beta.$$

Since this is larger than $(1 - x)\beta$, it is always optimal for the manager to choose $D = 1$.

(b) Assume that $\beta \geq \delta$ and $x \geq q^{FB}$. Using similar arguments as above, the manager's expected payoff from $D = 0$ is

$$x\beta + \delta, \tag{7}$$

while the manager's expected payoff from $D = 1$ is

$$\lambda[x(\beta + \delta) + (1 - x)\beta] + (1 - \lambda)(x\beta + \delta). \tag{8}$$

Subtracting (7) from (8) yields

$$\lambda(1 - x)(\beta - \delta). \tag{9}$$

This is non-negative because $\beta \geq \delta$, so the manager always discloses ($D = 1$).

(c) Assume that $\beta \geq \delta$ and $q_\beta \leq x < q^{FB}$. The manager's expected utility from $D = 0$ is

$$x\beta + \delta. \tag{10}$$

The manager's expected utility from $D = 1$ is

$$\lambda[x(\beta + \delta) + (1 - x)\beta] + (1 - \lambda)(1 - x)\beta. \tag{11}$$

It is optimal for the manager to choose $D = 1$ whenever

$$\lambda[x(\beta+\delta)+(1-x)\beta]+(1-\lambda)(1-x)\beta-x\beta-\delta \geq 0$$

$$\iff \beta-\delta \geq x(\beta(2-\lambda)-\lambda\delta)$$

Because $\beta \geq \delta$, the disclosure policy is to choose $D = 1$ whenever $x \leq \tau$ where

$$\tau = \frac{\beta-\delta}{\beta(2-\lambda)-\lambda\delta}.$$

Notice that the denominator is greater than the numerator. Also, this expression is greater than q_β, because as we let $\lambda \to 0$, the resulting limit goes to q_β.

Furthermore,

$$\frac{\partial\tau}{\partial\beta} = \frac{2\delta(1-\lambda)}{[\beta(2-\lambda)-\lambda\delta]^2} > 0,$$

and

$$\frac{\partial\tau}{\partial\lambda} = \frac{(\beta-\delta)(\beta+\delta)}{[\beta(2-\lambda)-\lambda\delta]^2} \geq 0.$$

Thus far, we have covered three cases for the strong board: (a) $x < q_\beta$, (b) $\beta \geq \delta$ and $x \geq q^{FB}$, and (c) $\beta \geq \delta$ and $q_\beta \leq x < q^{FB}$. The last remaining possibility is when $\beta < \delta$ and $x \geq q_\beta$. When $\beta < \delta$ and $q_\beta \leq x < q^{FB}$, the manager chooses $D = 0$ because the manager's expected payoff from $D = 1$ in (11) is always less than the manager's expected utility from $D = 0$ in (10). When $\beta < \delta$ and $x \geq q^{FB}$, the manager chooses $D = 0$ because (9) is (weakly) negative.

■

There are three reasons why the manager is willing to disclose information to a strong board, despite the fact that the board can take away the manager's private benefits. First, when $x < q_\beta$, the manager's private signal is a strong indicator that $S = B$, and absent any advice from the board, the manager does not obtain any private benefits. By disclosing to the board, the manager can obtain the board's advice, which results in reduced uncertainty and potentially information that allows the manager to obtain private benefits. Second, when $x \geq q^{FB}$, there is no conflict of interest for the manager to disclose information, so the manager discloses. Third, when $q_\beta < x \leq \tau$, there can be a conflict-of-interest problem, but the board's advice in reducing uncertainty is more valuable, so the manager chooses to disclose.

Interestingly, the manager does not disclose to the board when $\tau < x \leq q^{FB} = \frac{1}{2}$, which is when advising is potentially the most valuable, because uncertainty is highest. The reason is that this is the region where the conflict of interest for disclosure is also the highest.

Proposition 1 illustrates several important ideas. First, the manager discloses more with a weak board than with a strong board. This is because the strong board penalizes the manager when she does not take the first-best project, while the weak board does not. Second, equity incentives motivate disclosure. When the manager has higher equity incentives, she cares more about making the right project selection, so she discloses more to receive advice from the board. Third, higher board expertise makes it more valuable to seek advice from the board, which encourages the manager to disclose.

The next two lemmas examine the expected project payout when the board is weak or strong.

Lemma 4: Suppose the board is weak. If $\beta \geq \delta$, the expected project payout is

$$E[V] = \lambda + (1-\lambda)\left(\frac{3}{4} - \frac{\delta^2}{4\beta^2}\right). \tag{12}$$

If $\beta < \delta$, the expected project payout is $\frac{1}{2}$.

Proof. Suppose the board is weak. We begin with the case where $\beta \geq \delta$. From Proposition 1, the manager always chooses $D = 1$. Given $D = 1$, $A = 1$ occurs with probability λ. When $A = 1$, the manager chooses $I = 1$ if and only if $x + y \geq 1$ from Lemma 2, in which case $V = 1$. When $x + y < 1$, $S = B$ and the manager chooses $I = 0$ by Lemma 2, also yielding $V = 1$. Thus, the *ex-ante* project payout when $A = 1$ is 1.

When $A = 0$, the manager relies only on her own information x. Since there is no penalty for taking the wrong project under the weak board, the manager chooses $I = 1$ when $x \geq q_\beta$ and $I = 0$ when $x < q_\beta$ from Lemma 3. This yields expected project payout

$$E[V|Y = \emptyset] = (1 - q_\beta) \int_{q_\beta}^{1} x \left(\frac{1}{1 - q_\beta} \right) dx + q_\beta \int_{0}^{q_\beta} (1 - x) \left(\frac{1}{q_\beta} \right) dx = \frac{1}{2} + q_\beta - q_\beta^2,$$

where $1 - q_\beta$ is the probability that $x \geq q_\beta$, the conditional density function when $x \geq q_\beta$ is $\frac{1}{1-q_\beta}$, and the expected project payout is $x \cdot 1 + (1 - x) \cdot 0 = x$. Plugging in q_β from (5), we see that this expression is equal to $\frac{3}{4} - \frac{\delta^2}{4\beta^2}$. Combining the terms, we have

$$E[V] = \lambda E[V|Y = y] + (1 - \lambda)E[V|Y = \emptyset],$$

which yields (12).

Now, consider the case where $\beta < \delta$. In the case where $A = 1$, the manager chooses $I = 1$ regardless of whether the board's signal is favorable or unfavorable by Lemma 2. In the case where $A = 0$, notice that $\beta < \delta \Rightarrow q_\beta < 0$, so that she always takes the project from Lemma 3. In both cases, the expected project payout is $E[V] = \int_0^1 x dx = \frac{1}{2}$. ■

From Lemma 4, it is clear that the expected project payout is increasing with β. When β is below the threshold δ, the manager does not use the information that it (potentially) receives from the board to make better project decisions, but rather seeks to maximize her private benefits by taking the project. On the other hand, when β equals or exceeds δ, the manager takes the first-best project if she receives information from the board. By increasing β beyond δ, there is an additional benefit in that the firm is able to reduce the project distortion $(-\frac{\delta^2}{4\beta^2})$ in the case that the manager does not receive information from the board.

We next consider the expected project payout under the strong board.

Lemma 5: Suppose that the board is strong. The expected project payout is

$$E[V] = \begin{cases} \frac{3}{4} + \frac{\lambda}{4} & \text{if } \beta \geq \dfrac{\delta(2-\lambda)}{\lambda} \\ \tau + \frac{\lambda\tau^2}{2} - \tau^2 + \frac{1}{2} + \frac{\lambda}{8} & \text{if } \delta \leq \beta < \dfrac{\delta(2-\lambda)}{\lambda} \\ \frac{1}{2} & \text{if } \beta < \delta \end{cases}.$$

Proof. Consider first the case where $\beta \geq \frac{\delta(2-\lambda)}{\lambda}$. Since

$$\tau = \frac{\beta - \delta}{\beta(2-\lambda) - \lambda\delta} \geq \frac{1}{2} \iff \beta \geq \frac{\delta(2-\lambda)}{\lambda},$$

the manager chooses $D = 1$ for all x by Proposition 1. Thus, the board will learn y with probability λ. If the board's signal is favorable, the manager chooses $I = 1$ by Lemma 2, yielding $V = 1$. If the board's signal is unfavorable, the manager chooses $I = 0$, again yielding $V = 1$. Thus, $A = 1$ leads to $E[V] = 1$. When $A = 0$, the manager chooses $I = 1$ if and only if $x \geq \frac{1}{2}$ by Lemma 3. This yields

$$E[V|Y = \emptyset] = \frac{1}{2}\int_{\frac{1}{2}}^{1} x(2)dx + \frac{1}{2}\int_{0}^{\frac{1}{2}} (1-x)(2)dx = \frac{3}{4}$$

where $\frac{1}{2}$ is the probability that $x \geq \frac{1}{2}$, the conditional density function when $x \geq \frac{1}{2}$ is 2, and x is the expected project payout from $I = 1$.

Therefore, the expected project payout when $\beta \geq \frac{\delta(2-\lambda)}{\lambda}$ is

$$E[V] = \lambda + (1-\lambda)\frac{3}{4} = \frac{3}{4} + \frac{\lambda}{4}.$$

Next, suppose $\delta \leq \beta < \frac{\delta(2-\lambda)}{\lambda}$. There are three cases here: (i) $x \geq \frac{1}{2}$, (ii) $x \leq \tau$, and (iii) $\tau < x < \frac{1}{2}$. For (i), $D = 1$ from Proposition 1. If the board's signal is favorable (with probability $\frac{3}{4}\lambda$), then the manager chooses $I = 1$ from Lemma 2. If the board's signal is unfavorable (with probability $\frac{1}{4}\lambda$), the manager chooses $I = 0$ from Lemma 2. If $A = 0$, the manager chooses $I = 1$ from Lemma 3. Thus, the expected project payout is

$$E[V] = \lambda + (1-\lambda)\int_{\frac{1}{2}}^{1} x(2)dx = \lambda + (1-\lambda)\frac{3}{4}.$$

For (ii), the manager chooses $D = 1$ by Proposition 1. If the board's signal is favorable, which occurs with probability $\lambda\frac{\tau}{2}$, the manager chooses $I = 1$ from Lemma 2. If the board's signal is unfavorable, which occurs with probability $\lambda(1-\frac{\tau}{2})$, the manager chooses $I = 0$ from Lemma 2. If $A = 0$, the manager chooses $I = 0$ by Lemma 3. Thus,

$$E[V] = \frac{\lambda\tau}{2} + \lambda\left(1-\frac{\tau}{2}\right) + (1-\lambda)\int_{0}^{\tau}(1-x)\left(\frac{1}{\tau}\right)dx = \lambda + (1-\lambda)\left(1-\frac{\tau}{2}\right).$$

For (iii), the manager chooses $D = 0$ and $I = 1$, by Proposition 1 and Lemma 3, respectively. This yields

$$E[V] = \frac{1}{\frac{1}{2}-\tau}\int_{\tau}^{\frac{1}{2}} x dx = \frac{1}{2}\left(\frac{1}{2}+\tau\right),$$

where the conditional density function when $\tau < x < \frac{1}{2}$ is $\frac{1}{\frac{1}{2}-\tau}$, and x is the expected project payout from $I = 1$.

Combining cases (i), (ii), and (iii), we get the project's expected payout when $\delta \leq \beta < \frac{\delta(2-\lambda)}{\lambda}$ as

$$E[V] = \tau\left[\lambda + (1-\lambda)\left(1-\frac{\tau}{2}\right)\right] + \left(\frac{1}{2}-\tau\right)\left[\frac{1}{2}\left(\frac{1}{2}+\tau\right)\right] + \frac{1}{2}\left[\lambda + (1-\lambda)\frac{3}{4}\right]$$

$$= \tau\left(1-\frac{\tau}{2}+\frac{\lambda\tau}{2}\right) + \frac{1}{8} - \frac{\tau^2}{2} + \frac{3}{8} + \frac{\lambda}{8}$$

$$= \tau + \frac{\lambda\tau^2}{2} - \tau^2 + \frac{1}{2} + \frac{\lambda}{8}.$$

Finally, suppose $\beta < \delta$. In this case, the manager chooses $I = 1$, which yields $E[V] = \int_0^1 x dx = \frac{1}{2}$. ■

When β is "high," the manager always discloses to the board. Because the board is strong, the manager does not obtain any private benefits at the expense of the firm. Thus, firm value is independent of δ, and only depends on λ, the probability that the board learns y. When β is "medium," the manager discloses only for some realizations of x. Firm value is increasing with τ, the disclosure region. In this case, firm value does depend on δ, since τ is a function of δ. When β is "low," the manager never discloses, and since the board cannot monitor without information from the manager, she always takes the project, which gives her private benefits. It is easy to see that expected project payout is higher when β is higher.

4 Equilibrium Governance Mechanisms

Now, we move on to solve for the equilibrium level of equity incentives, and the equilibrium relations between the various governance mechanisms. First, we show the existence of an interior equilibrium for both weak and strong boards. Second, we characterize the equilibrium under weak and strong boards and examine properties of these equilibria. Finally, we compare firm value under weak and strong boards to understand optimal governance combinations. For the results in this section, we assume that private benefits δ are "small" relative to the magnitude of the project's payout: δ is no more than $\frac{1}{11}$ of the maximum project payout ($V = 1$). Formally,

Assumption 2: $\delta \leq \frac{1}{11}$.

Our first result is that there is an optimal interior level of equity incentives for both weak and strong boards. High equity incentives encourage the manager to disclose and obtain additional information from the board. Also, high equity incentives reduce the project selection distortion arising from private benefits. The cost of providing equity incentives is that the firm has fewer shares of the resulting payout of the project. The optimal level of equity incentives balances these forces.

Proposition 2 (Existence of Equilibrium): (i) For weak boards, there exists a unique interior equilibrium level of equity incentives $\beta_w \in [\delta, 1)$. (ii) For strong boards, there exists a unique interior equilibrium level of equity incentives

$$\beta_s \in \begin{cases} \left[\delta, \frac{\delta(2-\lambda)}{\lambda}\right] & \text{if } \dfrac{\delta(2-\lambda)}{\lambda} < 1 \\ [\delta, 1) & \text{if } \dfrac{\delta(2-\lambda)}{\lambda} \geq 1 \end{cases}.$$

Proof. (i) Suppose the board is weak. It is not optimal for $\beta_w \geq 1$, as the board's payoff (firm value) would then be at best zero, whereas it could achieve a positive payoff with $\beta_w < 1$. When $\beta_w < \delta$, the manager always takes the project from Lemmas 2 and 3, yielding $E[V] = \frac{1}{2}$. Since $E[V]$ is the same for all $\beta_w < \delta$, the board would prefer $\beta_w = 0$. When $\beta_w = 0$, firm value is $\Pi_w = \frac{1}{2}$ by Lemma 4.

Now, consider $\beta_w \geq \delta$. A sufficient condition for $\beta_w \geq \delta$ is that there exists some $k \geq \delta$ such that firm value when $\beta_w = k$ exceeds firm value when $\beta_w = 0$. From Lemma 4, when $\beta_w \geq \delta$ firm value is

$$\Pi_w(\beta) = (1-\beta)\left[\lambda + (1-\lambda)\left(\frac{3}{4} - \frac{\delta^2}{4\beta^2}\right)\right]. \tag{13}$$

Plugging $\beta_w = 2\delta$ into (13) yields

$$\Pi_w(2\delta) = (1-2\delta)\left(\lambda + (1-\lambda)\left(\frac{11}{16}\right)\right) > \frac{1}{2} \tag{14}$$

for any λ when Assumption 2 holds. Therefore, $\delta \leq \beta_w < 1$. Moreover, β_w is unique, because the second derivative of (13) with respect to β is

$$\frac{\partial^2 \Pi_w}{\partial \beta^2} = -\frac{\delta^2(3-\beta)(1-\lambda)}{2\beta^4},$$

which is negative for all $\delta \leq \beta < 1$. Thus, the board's objective function (13) is concave and has a unique maximum in the region.

(ii) Now suppose the board is strong. It is not optimal for $\beta_s \geq 1$, as the board's payoff would then be at best zero. Moreover, it is not optimal for $\beta_s > \frac{\delta(2-\lambda)}{\lambda}$, since by Lemma 5, the expected project payout is not increasing for $\beta_s > \frac{\delta(2-\lambda)}{\lambda}$.

Similar to the weak board, when $\beta_s = 0$, firm value is $\frac{1}{2}$. From Lemma 5, when $\delta \leq \beta_s \leq \frac{\delta(2-\lambda)}{\lambda}$, firm value is

$$\Pi_s(\beta) = (1-\beta)\left[\tau + \frac{\lambda\tau^2}{2} - \tau^2 + \frac{1}{2} + \frac{\lambda}{8}\right]. \tag{15}$$

A sufficient condition for $\beta_s \geq \delta$ is that we can find some $k \geq \delta$ such that firm value when $\beta_s = k$ exceeds firm value when $\beta_s = 0$. Note that (15) is increasing in λ, and when $\lambda = 0$, $\Pi_s(\beta)$ simplifies to $(1-\beta)(\frac{3}{4} - \frac{\delta^2}{4\beta^2})$. From (14) above, we know that at $\beta_s = 2\delta$, this expression is larger than $\frac{1}{2}$. Hence, $\delta \leq \beta_s \leq \frac{\delta(2-\lambda)}{\lambda}$. Moreover β_s is unique because the second derivative of (15) with respect to β is

$$-\frac{4\delta^2(1-\lambda)^2(6-(2-\lambda)\beta-(3+2\delta)\lambda)}{(\lambda\delta-(2-\lambda)\beta)^4} < 0.$$

Thus, the function is concave and has a unique maximum in the region. ■

When δ is sufficiently low, the equilibrium level of equity incentives is at least δ for both weak and strong boards. This is driven by the fact that higher equity incentives reduce project distortion when the manager does not receive information from the board and the board cannot effectively monitor the manager. This is the familiar role of equity incentives to align the manager's incentives with the firm's. Note that this force does not depend on the level of board expertise, λ.

Next, we examine the properties of the equilibria for both weak and strong boards.

Proposition 3 (Weak Board Equilibrium Properties): Suppose the board is weak. (1) If $\lambda \geq 1 - 2\delta$, then $\beta_w = \delta$. (2) If $\lambda < 1 - 2\delta$, then $\beta_w > \delta$ and β_w satisfies

$$(3+\lambda)\beta_w^3 + \delta^2(1-\lambda)\beta_w - 2\delta^2(1-\lambda) = 0,$$

with an increase in board expertise leading to a decrease in β_w (i.e., $\frac{\partial\beta_w}{\partial\lambda} < 0$).

Proof. (1) $\beta_w \geq \delta$ by Proposition 2. The first derivative of (13) with respect to β is

$$-\frac{1}{4\beta^3}\Big((3+\lambda)\beta^3 + \delta^2(1-\lambda)\beta - 2\delta^2(1-\lambda)\Big).$$

Evaluating at $\beta = \delta$ yields

$$\frac{1}{2\delta}\Big(1 - 2\delta - \lambda\Big),$$

which is non-positive when $\lambda \geq 1 - 2\delta$. Thus, $\beta_w = \delta$ as the function is concave (see the proof of Proposition 2).

(2) When $\lambda < 1-2\delta$, $\frac{1}{2\delta}(1-2\delta-\lambda) > 0$. Hence, $\beta_w > \delta$ and β_w satisfies the first-order condition from (13)

$$(3+\lambda)\beta^3 + \delta^2(1-\lambda)\beta - 2\delta^2(1-\lambda) = 0.$$

Using the implicit function theorem, we have

$$\frac{\partial \beta_w}{\partial \lambda} = \frac{\delta^2\beta_w - 2\delta^2 - \beta_w^3}{(3\beta_w^2 - \delta^2)\lambda + 9\beta_w^2 + \delta^2} = \frac{\beta_w^2(\delta^2 - \beta_w^2) - 2\delta^2}{(3\beta_w^2 - \delta^2)\lambda + 9\beta_w^2 + \delta^2} < 0$$

since $\beta_w > \delta$. ■

With information from the board, the manager would choose the first-best project policy when $\beta = \delta$, so any extra equity incentives would not be optimal for the firm. On the other hand, without information from the board, having $\beta > \delta$ can help reduce project distortion. Define

$$\hat{\lambda} \equiv 1 - 2\delta. \tag{16}$$

When board expertise is sufficiently high ($\lambda \geq \hat{\lambda}$), the likelihood that the manager has information about y is high, so the benefit of reduced expected project distortion is lower than the cost of equity compensation. However, when board expertise is sufficiently low ($\lambda < \hat{\lambda}$), the benefit of reducing project distortion exceeds the cost of additional equity compensation, so equilibrium equity incentives exceed δ. On the margin, as board expertise increases, the scenario where the manager is informed about y becomes more likely, so equilibrium equity incentives decline.

The next proposition characterizes the equilibrium under the strong board.

Proposition 4 (Strong Board Equilibrium Properties): Suppose the board is strong and $\lambda \geq \hat{\lambda}$. The equilibrium has the following properties:

(i) $\beta_s = \frac{\delta(2-\lambda)}{\lambda} > \delta$.

(ii) Full Disclosure: The manager discloses x to the board for all x.

(iii) Board expertise substitutes for equity incentives (i.e., $\frac{\partial \beta_s}{\partial \lambda} < 0$).

Proof. For part (i), the derivative of the board's objective function (15) evaluated at $\beta_s = \delta$ is

$$\frac{\partial \Pi_s}{\partial \beta} = \frac{4 - 4\delta - \delta(1-\lambda)(4+\lambda)}{8\delta(1-\lambda)} = \frac{4 - 8\delta + 3\lambda\delta + \lambda^2\delta}{8\delta(1-\lambda)}.$$

Because $\delta \leq \frac{1}{11}$, the above derivative is positive. Hence $\beta_s > \delta$. Evaluating the derivative of (15) at $\beta_s = \frac{\delta(2-\lambda)}{\lambda}$ yields

$$\frac{1}{\delta(1-\lambda)}\left(\frac{1}{16}\delta\lambda^3 + \frac{1}{16}\lambda^3 + \frac{1}{8}\lambda^2 + \frac{1}{2}\delta\lambda - \frac{3}{4}\delta\right)$$

$$> \frac{1}{\delta(1-\lambda)}\left(\frac{1}{80}\lambda^3 + \frac{1}{16}\lambda^3 + \frac{1}{8}\lambda^2 + \frac{1}{10}\lambda - \frac{3}{20}\right)$$

$$\sim \frac{1}{\delta(1-\lambda)}(6\lambda^3 + 10\lambda^2 + 8\lambda - 12).$$

The above expression is positive because $\lambda \geq \hat{\lambda} = 1 - 2\delta \Rightarrow \lambda \geq \frac{9}{11}$. Therefore, the derivative is positive at $\beta_s = \frac{\delta(2-\lambda)}{\lambda}$. Furthermore $\beta_s \leq \frac{\delta(2-\lambda)}{\lambda}$ since the expected project payout does not increase for larger β by Lemma 5. Therefore, $\beta_s = \frac{\delta(2-\lambda)}{\lambda}$.

For part (ii), Substituting $\beta = \frac{\delta(2-\lambda)}{\lambda}$ into (6) yields $\tau = \frac{1}{2}$, which means that the manager discloses x for all x by Proposition 1.

For part (iii), we find that as λ increases, $\beta_s = \frac{\delta(2-\lambda)}{\lambda}$ declines. Therefore, $\frac{\partial \beta_s}{\partial \lambda} < 0$.

■

When board expertise is sufficiently high, the strong board equilibrium features full disclosure by the manager. This occurs for two reasons. First, the manager highly values the advice of the board, so she is willing to disclose x, even though disclosing may reduce her expected private benefits. Second, the board is willing to incur higher costs of equity compensation ($\beta > \delta$), so that it can obtain information from the manager, which is required in order for the board's expertise to be effective. As board expertise increases above the threshold, the value of the board's advice becomes even more valuable to the manager, reducing the level of equity incentives needed to motivate disclosure.

Interestingly, board expertise and equity incentives are substitutes in both weak and strong boards, but for two different reasons. In weak boards, high board expertise increases the likelihood that the manager will be informed about the state of the world, and when the manager is informed, she is more likely to make the decision that maximizes firm value rather than the one that yields private benefits, reducing the need for equity incentives as motivation. In strong boards, the manager is more willing to forego the loss in private benefits for the board's advice when board expertise is higher, which reduces the need to use equity incentives to incentivize the manager to share information with the board.

Using the results from above, we have a sufficient condition for equilibrium equity incentives to be higher for strong boards than for weak boards.

Corollary 1: When $\lambda \geq \hat{\lambda}$, equilibrium equity incentives are higher for strong boards than for weak boards.

Greater board monitoring reduces the manager's incentives to disclose information to the board, so the firm uses more equity incentives to motivate the manager to disclose. For this to be true, board expertise may need to be sufficiently high, so that the benefit from motivating the manager to disclose exceeds the cost from issuing equity incentives.

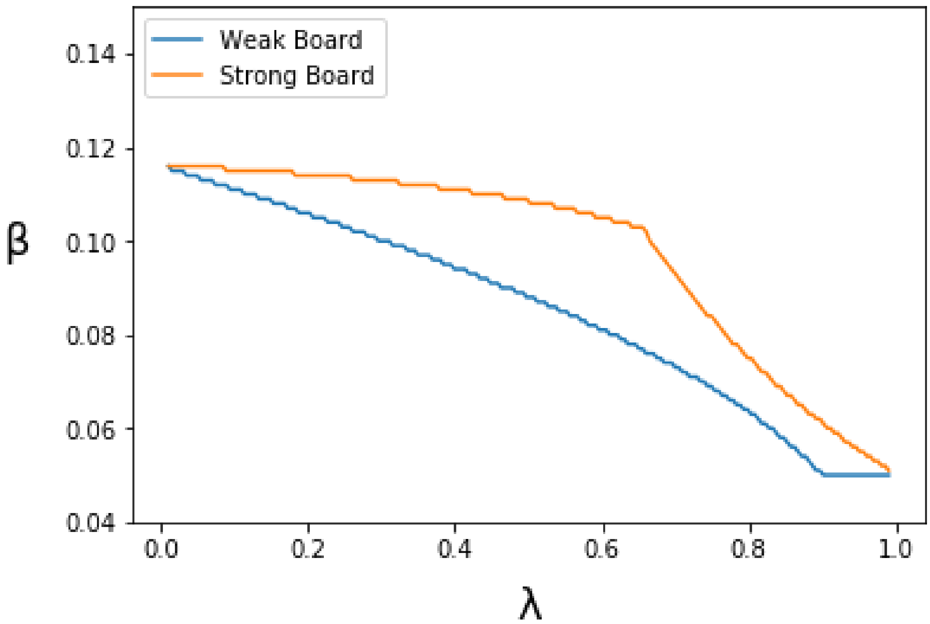

Figure 1: Equilibrium Equity Incentives for Weak and Strong Boards when $\delta = 0.05$

In Figure 1, we set $\delta = 0.05$ and solve the model numerically for different values of λ and plot the equilibrium level of equity incentives for both strong and weak boards. Consistent with Corollary 1, equity incentives are higher under strong boards than weak boards when $\lambda \geq \hat{\lambda} = 0.9$. Equilibrium equity incentives for the weak board are greater than δ when $\lambda < \hat{\lambda}$ and equal to δ when $\lambda \geq \hat{\lambda}$, consistent with Proposition 3. For both weak and strong boards, equilibrium equity incentives are monotonically decreasing with board expertise, consistent with Propositions 3 and 4. Finally, notice that while Corollary 1 holds under the sufficient condition that $\lambda \geq \hat{\lambda} = 0.9$, the figure suggests that this result holds more generally.

We also can show (numerically) that Corollary 1 can hold when we relax Assumption 2 that δ is relatively small. In Figure 2, we set $\delta = 0.30$ and solve the model numerically for different values of λ and plot the equilibrium level of equity incentives for both strong and weak boards. Consistent with Corollary 1, equity incentives are higher under strong boards than weak boards when $\lambda \geq \hat{\lambda} = 0.9$. Interestingly, we find that for lower λ, equilibrium equity incentives are higher for weak boards than for strong boards, suggesting a substitutive relation between equity incentives and board monitoring and board expertise is relatively low. The intuition for this is that when δ is relatively large and when board expertise is relatively low, it is too costly to motivate disclosure and motivate the manager to do select the right project without information. However, it is less costly to ensure the manager selects the right project with information, so the weak board uses greater equity incentives than the strong board.

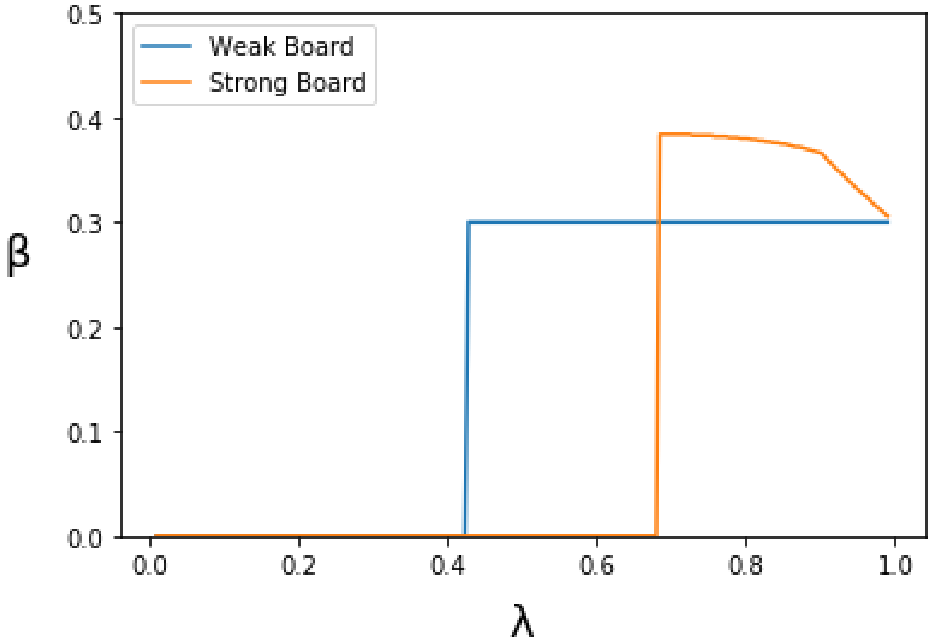

Figure 2: Equilibrium Equity Incentives for Weak and Strong Boards when $\delta = 0.30$

Up to now, we have taken board monitoring as given. Now, we ask the question, do firms prefer weak or strong boards *ex-ante*? We find that the answer depends critically on the level of board expertise, λ.

Proposition 5 (Strong vs. Weak Board): When $\lambda \geq \hat{\lambda}$, firm value is higher under strong boards than weak boards. Otherwise, firm value can be either higher or lower under weak boards than under strong boards.

Proof. By Propositions 3 and 4, $\beta_w = \delta$ and $\beta_s = \frac{\delta(2-\lambda)}{\lambda}$. Firm value under the weak board is

$$(1-\delta)\left(\frac{1}{2}+\frac{1}{2}\lambda\right), \tag{17}$$

while firm value under the strong board is

$$\left(1 - \frac{\delta(2-\lambda)}{\lambda}\right)\left(\frac{3}{4} + \frac{1}{4}\lambda\right). \tag{18}$$

Subtracting (17) from (18) yields

$$\frac{1}{4} - \frac{\lambda}{4} - \frac{3\delta}{2\lambda} + \frac{3\lambda\delta}{4} + \frac{3\delta}{4} > 0$$

$$\iff (1+3\delta)(\lambda - \lambda^2) + 6\delta(\lambda^2 - 1) > 0$$

$$\iff \lambda > \frac{6\delta}{1-3\delta}.$$

When δ satisfies Assumption 2, $\lambda \geq \hat{\lambda} = 1 - 2\delta \Rightarrow \lambda > \frac{6\delta}{1-3\delta}$. Thus, firm value is greater under the strong board is than under the weak board.

We prove the second part of the statement with example(s). Specifically, we numerically solve the model when $\delta = 0.05$ and $\lambda < \hat{\lambda}$ and show that firm value can be higher under weak boards than strong boards (See Figure 3 below). ■

Even with high board expertise, there is always a possibility that project distortion can occur when the manager does not receive information from the board. This distortion can be eliminated only in strong boards but not in weak boards. However, the downside of a strong board is that the board's monitoring discourages the manager to share information. When board expertise is high, it is relatively easy to induce the manager to disclose information. Firm value is higher with a strong board than with a weak board because the benefit of eliminating project distortion exceeds the cost of motivating disclosure. When board expertise is not particularly high, it may not be the case that strong boards have higher firm value than weak boards. In this case, the cost of motivating disclosure may exceed the benefit of eliminating project distortion.

In Figure 3, we set $\delta = 0.05$ and solve the model numerically for different values of λ and plot the resulting *ex-ante* firm values for weak and strong boards. Consistent with our proposition, firm value is higher under strong boards than weak boards when $\lambda \geq \hat{\lambda} = 0.9$. On the other hand, below this threshold, firm value can be higher under weak boards than strong boards.

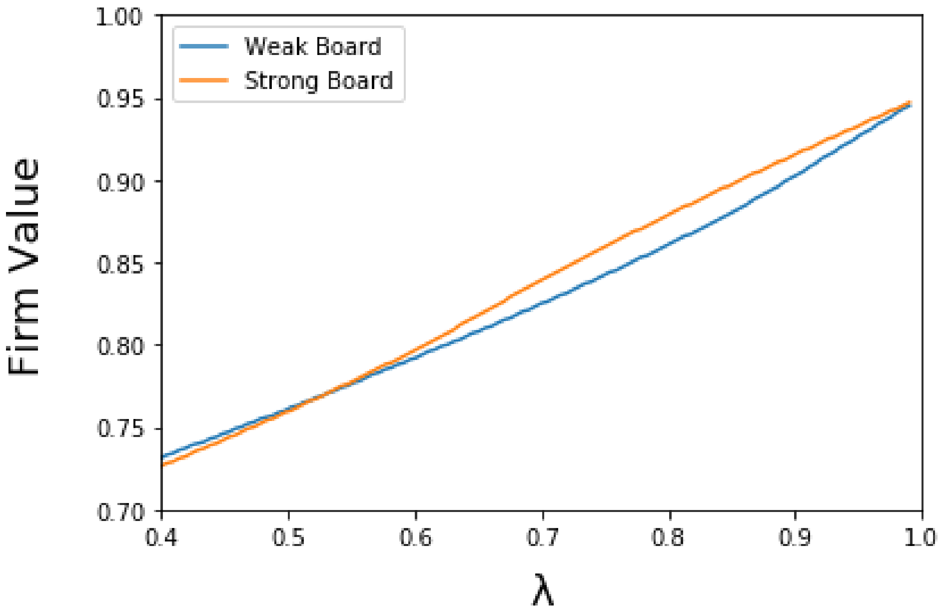

Figure 3: *Ex-Ante* Firm Value For Weak and Strong Boards

5 Discussion

In this section, we relax various assumptions from our main analysis in order to examine the robustness of our results, particularly whether equity incentives and board monitoring can still be complements. In order to make the following analysis tractable, we make a simplifying distributional assumption on x and y. Specifically, we assume that x takes the value of 1 and 0 with equal likelihood, while y is 1 and 0 with probability p and $1 - p$, respectively, with $p < \frac{1}{2}$. As before, the state is good when $x + y \geq 1$ and is bad otherwise. This makes the manager's optimal disclosure policy straightforward and allows us to extend the model in other dimensions.

5.1 Noisy Information

In our main analysis, when $x + y \geq 1$, the state is good with probability one. In this section, we allow for information to be noisy, which we capture using the parameter γ. When $x + y \geq 1$, with probability γ the state is good, and with probability $1 - \gamma$ the state is bad. When $x + y < 1$, with probability γ the state is bad, and with probability $1 - \gamma$ the state is good. $\gamma > \frac{1}{2}$. Higher γ means that information is less noisy and is thus more valuable.

In this setting, we find that as long as information is sufficiently precise, equity incentives and board monitoring are indeed complements when board expertise is high, as was the case in our main analysis.

Observation 1 (Noisy Information): Assume that $\frac{(2\gamma-1)^2}{2\gamma} > \frac{\delta}{1-p}$. Then, for sufficiently large λ, equilibrium equity incentives are higher for strong boards than for weak boards ($\beta_s > \beta_w$).

Proof. See Appendix.

This result provides an additional cross-sectional variable to consider when examining the correlation between board monitoring and equity incentives. When uncertainty is high and it is difficult to forecast the future state of the world, Observation 1 suggests that it is less likely to empirically observe a positive correlation between board monitoring and equity incentives.

5.2 Contracting on Disclosure

In our main analysis, we did not allow for equity incentives to depend on the manager's disclosure decision. In this section, we relax this assumption and allow the board to grant different levels of equity incentives as a function of the manager's disclosure. Specifically, equilibrium equity incentives are now a pair (β_{ND}, β_D) where β_{ND} is the level of equity incentives if the manager does not disclose, while β_D is the level of equity incentives if the manager does disclose. Intuitively, this contract should not make a difference for the weak board, as the manager is always willing to share information with the board. However, the more general contract could allow the strong board to more easily incentivize the manager to disclose, and thus it may be the case that equity incentives are no longer higher for strong boards. In the following, we show that equity incentives and board monitoring can again be complements.

Observation 2 (Contracting on Disclosure): When $\lambda < \frac{1}{2}$, δ is sufficiently small, and p is sufficiently large, equilibrium equity incentives are higher for the strong board than for the weak board ($\beta_D^s > \beta_D^w$).

Proof. See Appendix.

When the board can contract on disclosure, the information sharing friction becomes easier to solve for the strong board, holding everything else fixed. Thus, in order for equilibrium equity incentives to still be higher for the strong board, board expertise must be low, which makes the information coming from the board less valuable, so that the manager is less willing to give up private benefits to obtain information. In order for the strong board to find it optimal to motivate disclosure, the benefits from information sharing must exceed the cost of compensation, which occurs when the level of private benefits δ is low.

5.3 Generalized Monitoring

In our main analysis we assumed that if the manager did not take the first-best project, a strong board will remove all of the manager's private benefits (penalty δ), while a weak board will not remove any private benefits (penalty 0). We can relax this assumption and allow the board to commit to some stochastic monitoring technology θ, so that with probability θ, the board imposes penalty δ and with probability $1-\theta$, the board imposes penalty 0 if the manager does not make the first-best project selection. The strong and weak boards are special cases of this monitoring technology with $\theta = 1$ and $\theta = 0$, respectively. We assume that the manager observes the realization of this monitoring technology after the disclosure decision but before selecting the project. The following result shows how equilibrium equity incentives vary with board monitoring. We find that our main result that equity incentives and board monitoring can be complements is robust.

Observation 3 (Generalized Monitoring): Suppose that the board chooses monitoring intensity $\theta \in [0, 1]$. Then, for sufficiently large p, as monitoring intensity increases, equilibrium equity incentives also increase.

Proof. See Appendix.

6 Empirical Implications

There is a large empirical literature in corporate governance (see e.g., Adams et al., 2010; Armstrong et al., 2015 for recent surveys). However, most papers in this literature typically attempt to isolate a single governance mechanism and assess whether it increases firm performance/value. Little is known about how individual governance mechanisms are related to each other. Our model offers new testable empirical predictions about the relations between equity incentives, board monitoring, board expertise, and managerial information acquisition.

Prediction 1. Equity incentives and board monitoring are positively related provided that board expertise exceeds some threshold.

This prediction follows from Corollary 1. Greater board monitoring reduces the manager's incentives to disclose information to the board, so the firm uses equity incentives to motivate the manager to disclose. Board expertise needs to be sufficiently high, so that the benefit from motivating the manager to disclose exceeds the cost from issuing equity incentives.

To evaluate this empirically, one can first partition the sample into "high" and "low" subsamples of board expertise. There are many existing measures of board expertise, such as financial expertise, related-industry expertise (Dass et al., 2014), and executive expertise. Furthermore, Regulation S-K contains detailed expertise information about individual directors, which can allow researchers to construct novel measures of board expertise (Adams et al., 2018).

Next, ideally one could find some source of plausibly exogenous variation in board monitoring. For example, Armstrong et al. (2014) use a shock to the proportion of independent directors to examine the effect of director independence on corporate transparency. To the extent that an increase in board independence increases board monitoring, our model predicts that equity incentives should increase following the shock to board independence for firms in the "high" subsample of board expertise. Note that it is certainly possible that equity incentives and board monitoring are positively related in the "low" subsample of board expertise. In fact, Figure 2 suggests that this should be the case. However, Prediction 1 only applies to the "high" subsample of board expertise.

Prediction 2. Equity incentives are negatively related to board expertise provided that board expertise exceeds some threshold.

This prediction follows from Propositions 3 and 4. There are two reasons for this prediction. First, when board expertise is high, the manager is more willing to forego the loss in private benefits for the board's advice, which reduces the need to use equity incentives to incentivize the manager to share information with the board. Second, high board expertise increases the likelihood that the manager will be informed about the state of the world. When the manager is informed, she is more likely to make the decision that maximizes firm value rather than the one that only yields private benefits, so less equity incentives are needed to resolve the incentive misalignment problem. To the best of our knowledge, no study has yet tested this hypothesis.

Prediction 3. Board expertise and board monitoring are positively related provided that board expertise exceeds some threshold.

This prediction follows from Proposition 5. Even with high board expertise, there is always a possibility that project distortion can occur when the manager does not receive information from the board.[7] This distortion is eliminated in strong boards but not in weak boards, as the strong board commits to penalizing the manager when she does not take the first-best project policy. However, the cost of a strong board is that the board's monitoring discourages the manager to share information. When board expertise is high, it is relatively easy to induce the manager to disclose information. As a result, firm value is higher with a strong board than with a weak board because the benefit of eliminating project distortion exceeds the cost of motivating disclosure.

Prediction 4. Equity incentives are positively related to managerial information acquisition when board monitoring is high.

This prediction follows from Proposition 1. Proposition 1 shows that as equity incentives increase, the manager cares more about making the right project selection and is thus more willing to acquire additional information. The manager does this in our model by sharing her private information with the board, despite the fact that a strong board can use that information to more effectively monitor the manager.

While board expertise, board monitoring, and equity incentives have straightforward empirical proxies, it is more difficult to construct an empirical proxy for managerial information acquisition. One possibility is to use management forecast errors, where lower errors correspond to managers who are more informed about industry and economic conditions (e.g., Goodman et al., 2014). However, management forecasts errors are likely affected by other factors outside of the model. To mitigate this concern, researchers could follow the two-step matching procedure described in Armstrong et al. (2010) to examine the association between equity incentives and management forecast errors.

An alternative approach would be to test the prediction indirectly. A central result in disclosure theory is that when managers become more informed, they should disclose more information (Verrecchia, 1990). Combining this intuition with our model's results suggests that there should be a positive relation between equity incentives and measures

[7] Recall that after the manager shares information with the board, a board with expertise λ learns about y with probability λ and does not learn about y with probability $1 - \lambda$.

of corporate transparency, for which there are many empirical proxies (Armstrong et al., 2014).

7 Conclusion

We model equilibrium relations among four key governance mechanisms: board monitoring, board expertise, information acquisition, and equity incentives. Our model predicts that equity incentives are positively related to managerial information acquisition and negatively related to board expertise. Our model also predicts that equity incentives and monitoring can be complements.

A key theoretical insight from our analysis is that equity incentives encourage managers to acquire additional information to improve their decision making, even at the expense of private benefits. This is the critical link that connects equity incentives with board structure in our model. This role of equity incentives has been underexplored in the literature and can have broad implications. For instance, a straightforward application of this idea can help explain why equity incentives may be related to corporate transparency, management forecast errors, and other aspects of external reporting.

While we have focused on four salient governance mechanisms, future research can apply our approach to study other dials of corporate governance, including staggered boards, corporate culture, shareholder monitoring, auditing, and so on. More research on their endogenous relations can help us better understand how firms formulate their governance structures.

Appendix: Omitted Proofs

Proof of Observation 1. First, we derive optimal equity incentives under the weak board. When $x = 1$ and y is unknown (or known), the manager will take the project. Next, when $x = 0$ and y is unknown, the expected project payout from not taking the project is $(1-p)\gamma+p(1-\gamma)$, while the payout from taking the project is $p\gamma+(1-p)(1-\gamma)$. Thus, the first-best project policy involves not taking the project. The manager will not take the project if and only if

$$\beta[(1-p)\gamma + p(1-\gamma)] \geq \beta[p\gamma + (1-p)(1-\gamma)] + \delta \iff \beta \geq \frac{\delta}{(1-2p)(2\gamma-1)},$$

where $\beta[(1-p)\gamma+p(1-v)]$ is the manager's expected payoff from not taking the project, while the term on the right side of the inequality is the manager's expected payoff from taking the project.

When $x = 0$ and y is known to be 0, the manager will not take the project when

$$\beta\gamma \geq \beta(1-\gamma) + \delta \iff \beta \geq \frac{\delta}{2\gamma-1}.$$

Finally, when $x = 0$ and y is known to be 1, the manager will take the project. From the manager's project policy, we can write the *ex-ante* expected firm value as a function of β:

$$\text{FV} = \begin{cases} \frac{1}{2}(1-\beta)[\gamma + \lambda\gamma + (1-\lambda)[(1-p)\gamma + p(1-\gamma)]] & \text{when } \beta \geq \dfrac{\delta}{(1-2p)(2\gamma-1)} \\ \frac{1}{2}(1-\beta)[\gamma + \lambda\gamma + (1-\lambda)[p\gamma + (1-p)(1-\gamma)]] & \text{when } \dfrac{\delta}{2\gamma-1} \leq \beta < \dfrac{\delta}{(1-2p)(2\gamma-1)} \\ \frac{1}{2}(1-\beta)[\gamma + p\gamma + (1-p)(1-\gamma)] & \text{when } \beta < \dfrac{\delta}{2\gamma-1} \end{cases}.$$

The firm's objective is to select β to maximize this equation. Because each expression above is decreasing in β, we can simplify the firm's optimization problem by substituting in for β using the lower bound of each interval and state the problem as $\max\{I, II, III\}$

where

$$I = \left(1 - \frac{\delta}{(1-2p)(2\gamma-1)}\right)(\gamma + \lambda\gamma + (1-\lambda)((1-p)\gamma + p(1-\gamma)))$$

$$II = \left(1 - \frac{\delta}{2\gamma-1}\right)(\gamma + \lambda\gamma + (1-\lambda)(p\gamma + (1-p)(1-\gamma)))$$

$$III = \gamma + p\gamma + (1-p)(1-\gamma).$$

Because

$$\Delta = \lim_{\lambda\to 1}(II - I) = \left(\frac{\delta}{(1-2p)(2\gamma-1)} - \frac{\delta}{2\gamma-1}\right)(2\gamma) > 0,$$

there exists some $\lambda_1 \in (0,1)$ such that $II > I$ for all $\lambda > \lambda_1$, which then immediately implies that $\beta_w \leq \frac{\delta}{2\gamma-1}$.

Now, we derive optimal equity incentives under the strong board. When $x = 1$, the manager will take the project and disclosure is irrelevant. Next, consider the case when $x = 0$. We first note that in equilibrium it is never the case that the manager does not disclose and also does not take the project (disclosing would yield a profitable deviation). Thus, given non-disclosure, the manager must take the project in equilibrium. The manager's expected payoff when not disclosing is

$$\beta(p\gamma + (1-p)(1-\gamma)) + \delta,$$

while her expected payoff from disclosing is

$$\beta(\lambda\gamma + (1-\lambda)((1-p)\gamma + p(1-\gamma))) + \lambda p\delta.$$

Thus, the manager will disclose if and only if

$$\beta \geq \frac{(1-\lambda p)\delta}{(1-2p+\lambda p)(2\gamma-1)}.$$

When the manager does not receive information from the board (with probability $1-\lambda$), she does not take the project due to the strong board's monitoring, so the expected project payoff is $(1-p)\gamma + p(1-\gamma)$.

From the manager's project policy, we can write out the *ex-ante* expected firm value as a function of β

$$\text{FV} = \begin{cases} \frac{1}{2}(1-\beta)(\gamma + \lambda\gamma + (1-\lambda)((1-p)\gamma + p(1-\gamma))) & \text{when } \beta \geq \dfrac{(1-\lambda p)\delta}{(1-2p+\lambda p)(2\gamma-1)} \\ \frac{1}{2}(1-\beta)(\gamma + (p\gamma + (1-p)(1-\gamma)) & \text{when } \beta < \dfrac{(1-\lambda p)\delta}{(1-2p+\lambda p)(2\gamma-1)} \end{cases}.$$

Because each expression above is decreasing in β, we can simplify the firm's optimization problem to $\max\{I, II\}$ where

$$I = \left(1 - \frac{(1-\lambda p)\delta}{(1-2p+\lambda p)(2\gamma-1)}\right)(\gamma + \lambda\gamma + (1-\lambda)((1-p)\gamma + p(1-\gamma)))$$

$$II = \gamma + p\gamma + (1-p)(1-\gamma).$$

Because

$$\Delta = \lim_{\lambda \to 1}(I - II) = \left(1 - \frac{\delta}{2\gamma - 1}\right)(2\gamma) - (\gamma + p\gamma + (1-p)(1-\gamma)) > 0$$

when $\frac{(2\gamma-1)^2}{2\gamma} > \frac{\delta}{1-p}$ as assumed, there exists some $\lambda_2 \in (0,1)$ such that for all $\lambda > \lambda_2$, $I > II$ and $\beta_s = \frac{1-\lambda p}{1-2p+\lambda p} \cdot \frac{\delta}{2\gamma-1}$. Therefore, there exists $\hat{\lambda} = \max\{\lambda_1, \lambda_2\}$ such that for all $\lambda > \hat{\lambda}$, $\beta_s > \beta_w$ because $\frac{1-\lambda p}{1-2p+\lambda p} > 1$. ∎

Proof of Observation 2. Suppose the board is weak. Consider the following menu of contracts: $(\beta^w_{ND}, \beta^w_D) \in \{(0,0), (0,\delta), (0, \frac{\delta}{1-2p})\}$. One can easily verify that under $(0,0)$ the manager always takes the project, under $(0,\delta)$ the manager makes the first-best project selection with information about y, and under $(0, \frac{\delta}{1-2p})$ the manager always makes the first-best project selection with or without knowledge of y. To determine equilibrium equity incentives, it suffices to examine which of the above contracts is optimal from the firm's perspective.

From the manager's project policy, we can write out the *ex-ante* expected firm value as a function of the contracts

$$\text{FV} = \begin{cases} \frac{1}{2}\left(1 - \frac{\delta}{1-2p}\right)(1 + \lambda + (1-\lambda)(1-p)) & \text{for contract } \left(0, \dfrac{\delta}{1-2p}\right) \\ \frac{1}{2}(1-\delta)(1 + \lambda + (1-\lambda)p) & \text{for contract } (0, \delta) \\ \frac{1}{2}(1+p) & \text{for contract } (0, 0) \end{cases}.$$

For sufficiently large p, we see that contract $(0, \delta)$ yields higher firm value than contract $(0, \frac{\delta}{1-2p})$. Hence, optimal equity incentives for the weak board must be $\beta_D^w \leq \delta$.

Now, suppose the board is strong. Consider a contract of the form $(\beta_{ND}^s, \beta_D^s) = (0, \frac{(1-\lambda p)\delta}{1-(1-\lambda)p})$. The manager discloses when $x = 0$ since

$$\delta \leq \beta(\lambda + (1-\lambda)(1-p)) + \lambda p \delta \iff \beta \geq \frac{(1-\lambda p)\delta}{1-(1-\lambda)p}$$

where the expected payoff from not disclosing is now δ because the manager does not receive any equity incentives from non-disclosure. Since $\lambda < \frac{1}{2}$ by assumption, $\frac{(1-\lambda p)\delta}{1-(1-\lambda)p}$ is greater than δ.

It only remains to check that it is optimal from the firm's perspective to motivate disclosure for $\lambda < \frac{1}{2}$. It is efficient for the firm to motivate the manager to disclose if and only if

$$\frac{1}{2}\left(1 - \frac{(1-\lambda p)\delta}{1-(1-\lambda)p}\right)(1 + \lambda + (1-\lambda)(1-p)) \geq \frac{1}{2}(1+p)$$

Since the term on the left is increasing with λ, we can derive a sufficient condition by setting $\lambda = 0$. Doing this yields

$$\delta \leq \frac{1-2p}{2-p}.$$

Thus, for sufficiently small δ, the strong board still finds it optimal to motivate disclosure.

■

Proof of Observation 3. With generalized monitoring, the firm's optimization problem becomes selecting a level of equity incentives given monitoring intensity θ such that the manager is willing to share information with the board, while minimizing the cost of compensation. When $x = 1$, the level of monitoring is irrelevant. Suppose $x = 0$. Given monitoring intensity θ and equity incentives β, the manager is willing to disclose if and only if

$$\beta p + \delta \leq \beta[\lambda + (1-\lambda)(\theta(1-p) + (1-\theta)p)] + (\lambda p + (1-\lambda)(1-\theta))\delta$$

Note that with monitoring level θ, the expected project payout is $\theta(1-p) + (1-\theta)p$ where with probability θ, the manager does not take the project and with probability $1-\theta$, the manager takes the project. This inequality can be simplified to

$$\beta \geq \frac{[\theta(1-\lambda) + \lambda(1-p)]\delta}{\theta(1-\lambda)(1-2p) + \lambda(1-p)}.$$

As long as δ is sufficiently small, it is optimal for the firm to motivate the manager to disclose. As a result, equilibrium equity incentives will be such that the above inequality is binding. Taking the first derivative of the threshold with respect to θ yields

$$C\lambda(1-\lambda)(1-p)(2p) > 0.$$

where C is some positive constant that is a function of θ, p, λ, and δ. Therefore, as monitoring intensity increases, equilibrium equity incentives also increase. ■

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