RFS Advance Access published March 3, 2008

Who Monitors the Monitor? The Effect of Board Independence on Executive Compensation and Firm Value

Praveen Kumar and K. Sivaramakrishnan
University of Houston

Recent corporate governance reforms focus on the board's independence and encourage equity ownership by directors. We analyze the efficacy of these reforms in a model in which both adverse selection and moral hazard exist at the level of the firm's management. Delegating governance to the board improves monitoring but creates another agency problem because directors themselves avoid effort and are dependent on the CEO. We show that as directors become less dependent on the CEO, their monitoring efficiency may decrease even as they improve the incentive efficiency of executive compensation contracts. Therefore, a board composed of directors that are more independent may actually perform worse. Moreover, higher equity incentives for the board may increase equity-based compensation awards to management. (*JEL* G31, G34, D82)

The performance of corporate boards has come under scrutiny in recent years, following a wave of corporate scandals. There is major concern that CEOs wield an inordinate influence on the board's constitution and functioning and that directors are excessively dependent on the management (e.g., Crystal, 1991; Bebchuk and Fried, 2004; and Morgensen, 2005). Indeed, regulatory bodies such as the SEC, along with the NYSE and the NASDAQ, have instituted a number of reforms to promote the board's independence. Both the NYSE and the NASDAQ now require that a majority of directors on corporate boards should be independent, and that only independent directors should serve on the audit and compensation subcommittees.[1] At the same time, there is a notable

We thank the editor, Bob McDonald, and an anonymous referee for very helpful comments. We also thank Sandeep Baglia, Bala Balchandran, Joel Demski, Douglas Gale, Ed Green, Steve Huddart, Kose John, Sok-Hyon Kang, Paul MacAvoy, Todd Milbourn, Dilip Mookherjee, John O'Brien, Madhav Rajan, Stefan Reichelstein, Susan Spring, Shyam Sunder, Jean Tirole, Donna Zerwitz, and participants at the 2003 Summer Econometric Society meetings and the 2004 CMU Accounting Conference for comments and discussions on issues addressed in the paper. Address correspondence to Praveen Kumar, University of Houston, C.T. Bauer College of Business, Houston, TX 77204-2016; telephone: (713) 743-4770; fax: (713) 743-4789; e-mail: pkumar@uh.edu

[1] While the board's independence fundamentally relates to the extent to which directors' interests are aligned with the interests of the CEO, these governance reforms define the board's independence from the viewpoint of verifiability. For example, the New York Stock Exchange Listing Standards define a director's independence as the absence of material connection with the firm—either directly or as a partner, shareholder, or officer of an organization that has a relationship with the company (see, e.g., Bainbridge, 2002).

doi:10.1093/rfs/hhn010

upward trend in equity-based incentive awards to directors (Black and Bhagat, 2002; Conference Board, 2002; and Pearl Meyer & Partners, 2005).[2]

A basic premise underlying these regulatory reforms and equity-based incentives is that they unambiguously improve the board's performance from a shareholder's perspective. However, using an agency model of the firm to capture the board-CEO relationship, this paper shows that a board composed of directors that are less dependent on the CEO may actually perform worse.

In this model, the CEO (the "manager") has private information on the firm's economic prospects and his own expenditure of effort. The board performs two main functions—monitoring and contracting.[3] It undertakes costly monitoring to generate independent information on the firm's economic prospects. Using the information generated by monitoring, it contracts with the manager on behalf of shareholders. This contract determines the manager's capital investment decision, effort, and compensation.

The directors' contribution to shareholder value depends on the extent of monitoring effort that they expend, and how close their chosen contract is to the one that maximizes shareholder value. However, delegating governance to the board creates a new agency problem because of the directors' own effort-aversion and their dependence on the manager.[4] We define a representative director's dependence on the manager by the extent to which the director receives her utility from the manager's utility. We allow shareholders to award equity incentives to the directors as a way to ameliorate this agency problem. Because the director's dependence and equity incentives determine her monitoring and contracting performance, we are able to examine the influence of the director's dependence on shareholder value.

Our principal finding is that the representative director's contribution to shareholder value can improve even as her dependence on the manager increases. The reason is that the director's dependence on the manager can influence her monitoring and contracting performance in offsetting ways. Therefore, the relationship between the director's dependence and performance is ambiguous.

---

[2] In a survey of 558 corporations, the Conference Board in its 2002 research report finds that 84% of the companies make some form of stock payment to outside directors. In manufacturing companies, this figure increases to 91%. And in their annual survey of director compensation in 200 major US industrial and service firms in 2005, the compensation consultants Pearl Meyer & Partners report a 58% increase in the value of stock awards to directors between 2004 and 2005.

[3] We focus on these two roles specifically, because the literature on corporate governance views them as important responsibilities of the board (e.g., Black, 2000; Van Den Berghe and Levrau, 2004; and Anand, 2005).

[4] CEOs typically control the nomination and reelection of directors to the board. Once on the board, directors become further dependent on the CEO to avail themselves of pecuniary and nonpecuniary benefits that accrue with board membership (e.g., Main, O'Reilly, and Wade, 1995; and Hermalin and Weisbach, 1998). Moreover, directors and CEOs are often corporate elites who share repeated professional and social interactions, thus engendering a "community of interest" and "commonality of outlook" (see Mills, 2000). The common practice of *interlocking boards*, whereby a director is an executive at a firm on whose board the CEO sits, also exacerbates the board's dependence on the CEO (e.g., Zajac and Westphal, 1996; and Fitch and White, 2001).

To understand the intuition behind this ambiguous result, consider first the effect of dependence on the representative director's contracting performance. A more dependent director will choose a contract that is closer to the manager's personal preference, which is detrimental to shareholder value. But this choice also imposes a personal wealth cost on the director whenever she has an equity stake in the firm, because it lowers the value of that stake. Consider next the relationship between dependence and the representative director's monitoring performance. Other things held fixed, a more dependent director is less inclined to monitor the manager compared to a less dependent director. However, in equilibrium, a more dependent director increases her monitoring effort *ex ante* to offset the wealth cost from her poorer contract choice *ex post*. Therefore, the overall effect of the director's dependence on her monitoring performance is ambiguous. Since this analysis applies to any director on the board, it follows that the effect on shareholder value of varying board composition to decrease the average level of director's dependence is also ambiguous.

The influence of the board's dependence and the manager's equity-based compensation is also of substantial interest (e.g., Bebchuk and Fried, 2004). We find that the equilibrium relationship between the representative director's dependence and the size of the manager's equity-based compensation is ambiguous. Because of asymmetric information, the incentive-efficient compensation contract for the manager must tolerate some investment inefficiency from the standpoint of shareholder value. If the cost of such investment inefficiency is sufficiently high, as is likely for high-growth-option firms, a less dependent director with an equity stake may award higher equity compensation to the manager to better align the manager's interests with shareholder value maximization.

For related reasons, increasing equity incentives for the representative director does not necessarily result in lower equity-based managerial compensation. In fact, higher equity incentives for the directors may increase equity-based compensation to the manager, in equilibrium. Thus, simply increasing the directors' equity ownership may not be a general solution to board performance problems.

In related work, a large body of theoretical and empirical corporate governance literature has examined the relation between the board's independence and shareholder value. Hermalin and Weisbach (1998) model the board's decision to acquire costly information about the CEO's ability and whether to retain or replace a CEO based on the firm's performance. In their model, the board's dependence does not directly influence the design of the CEO's compensation contract. Thus, they do not obtain the ambiguous relation between the board's dependence and shareholder value that we find.

Harris and Raviv (forthcoming) present a model that allocates control of the board to either insiders—the dependent board—or outsiders—the independent board. Both insiders and outsiders have private payoff-related information, and the model indicates that it is sometimes beneficial to give board control to

insiders in order to better exploit their superior, and less costly, information. By contrast, we consider a board whose dependence ranges all the way from complete to none at all, and we obtain an ambiguous relation between the board's dependence and its performance without assuming any direct link between the board's dependence and the cost of information acquisition.

In sum, the analysis of the effect of the board's dependence on its monitoring effort and contract design, with endogenously determined equity incentives for management and directors, distinguishes our analysis from the extant theoretical corporate governance literature. Our analysis is also consistent with the empirical literature that finds an ambiguous relationship between the board's independence and the firm's performance (e.g., Brickley, Coles, and Terry, 1994; Yermack, 1996; and Black and Bhagat, 2002).

The paper proceeds as follows. Section 1 describes the basic model, and Section 2 derives some useful benchmark allocations. Section 3 characterizes the board's performance and the equity incentives for the board in equilibrium, and Section 4 examines the relationship between gains from delegation and the director's independence. Section 5 discusses some extensions, and Section 6 concludes.

1. The Model

1.1 Technology and informational structure

We model the investment decision of a widely held and unlevered firm controlled by a risk-neutral manager. The firm has a technology that stochastically translates an investment I and a productive action a (effort) from the manager into future profit. The profit function is

$$Z(I, a; \beta) = \beta \log(Ia) - I + \varepsilon, \beta \in \{\beta_L, \beta_H\}, \qquad \beta_H > \beta_L. \tag{1}$$

In this profit function, β is a capital productivity parameter that the manager observes before making the investment. The common prior probability of the high-productivity state (β_H) is p. The profit shock ε is realized subsequent to the investment—it has an infinite support with a cumulative distribution function, $F(\varepsilon)$. We assume that the expected profit is finite for any triplet $\{I, a, \beta\}$.[5]

Outside shareholders do not observe either the productivity parameter (β) or the manager's chosen effort (a). The investment (I) and the output (Z) are publicly observable but do not perfectly reveal the manager's private information.

1.2 Managerial preferences

The manager derives a private benefit from undertaking larger projects. The monetary equivalent of this benefit is ϕI, where ϕ is a small positive number.

[5] For convenience, we use a simple form for the production function: $f(I, a) = \log(Ia)$. However, our main results readily extend to general parameterizations of $f(I, a)$ that satisfy $f_I(I, a) > 0$, $f_a(I, a) > 0$, $f_{II}(I, a) < 0$, $f_{aa}(I, a) < 0$, $f_{Ia}(I, a) \geq 0$.

This captures the well-known "empire building" incentives associated with corporate management (e.g., Stulz, 1990; and Hart, 1995). The manager also incurs a disutility $\mu a, \mu > 0$, from undertaking the productive effort a. Thus, if the manager's expected compensation from the firm is ϖ, then his total utility from managing the firm—which we denote by U^M—is

$$U^M = \varpi + \phi I - \mu a. \tag{2}$$

The manager has outside opportunities, and his reservation utility for managing the firm is given by some non-negative quantity $\overline{U}$.

1.3 Generalized agency and contracting

There is a conflict of interest between the manager and the shareholders because of the manager's preference for larger projects and disutility for effort. This conflict of interest, together with the asymmetric information about (β, a), generates an agency problem. Both adverse selection and moral hazard exist at the level of the firm's management; i.e., shareholders face a *generalized agency* problem (see Myerson, 1982), requiring the shareholders or their representatives to employ appropriate incentive contracts for the manager.

The generalized revelation principle facilitates our analysis of optimal contract design (Myerson, 1982; and Faynzilberg and Kumar, 1997, 2000). It allows us to restrict our attention to the class of *direct communication and obedience* contracts. In such contracts, the manager truthfully reports his type (β_L or β_H) and obeys instructions with respect to a. A contract for the manager is a menu that specifies, for each productivity report, the investment level, managerial effort, and managerial compensation composed of fixed salary and equity in the liquidating profits of the firm.

Therefore, a contract is the profile $\delta \equiv \langle \delta_i = \gamma_i, t_i, I_i, a_i \rangle$, $i \in \{L, H\}$. If the manager reports β_i, $i \in \{L, H\}$, then $t_i \in R$ and $0 \leq \gamma_i \leq 1$ are the lump-sum payment (positive or negative) and the fraction of equity awarded to him, respectively; I_i and a_i denote the investment and effort levels prescribed to him.

If the equity fraction $\gamma_i < 1$, then the shareholders receive $(1 - \gamma_i)$ share of the liquidating profits. However, if the fraction $\gamma_i = 1$, then the outsiders effectively sell the firm to the manager and receive t_i from him; i.e., $t_i < 0$ and represents the sale price of the firm (see, e.g., Harris and Raviv, 1979). Hence, the shareholders' payoffs in (productivity) state i, which we denote by V_i, are[6]

$$V_i = \begin{cases} (1 - \gamma_i)[\beta_i \log(I_i a_i) - I_i - t_i] & \text{if} \quad 0 \leq \gamma_i < 1 \\ -t_i (t_i < 0) & \text{if} \quad \gamma_i = 1. \end{cases} \tag{3}$$

[6] Note that outsiders are exposed to profit risk only if $\gamma_i < 1$. However, outsiders receive a fixed payment of $-t_i$ when $\gamma_i = 1$. Thus, there is a discontinuity in shareholders' expected payoffs at $\gamma_i = 1$.

Therefore, the shareholders' expected payoffs under δ are represented by the outside equity value (see, e.g., Fluck, 1998; and Myers, 2000), $V = pV_H + (1-p)V_L$.

Next, using Equation (2) above, we can compute the manager's utility, U^M, under the contract δ. Let U^M_{ij} denote the manager's utility when the true productivity is β_i, but he reports β_j, $i, j = L, H$. Let $a_{ij}(\psi_j)$ be the manager's optimal effort when the true productivity is i, and he receives the allocation $\psi_j = \langle \gamma_j, t_j, I_j \rangle$. Then,

$$U^M_{ij} = \gamma_j[\beta_i \log(I_j a_{ij}(\psi_j)) - I_j - t_j] + t_j + \phi I_j - \mu a_{ij}(\psi_j). \tag{4}$$

Therefore, $a_{ij}(\psi_j)$ solves

$$a_{ij}(\psi_j) \in \arg\max_a \{\gamma_j[\beta_i \log(I_j a) - I_j - t_j] + t_j + \phi I_j - \mu a\}. \tag{5}$$

Straightforward calculations show that

$$a_{ij}(\psi_i) = \frac{\beta_i \gamma_j}{\mu}. \tag{6}$$

For notational ease, let $U^M_i = U^M_{ii}$ and $a_i = a_{ii}$.

1.4 Delegated contracting and information generation

Our objective in this paper is to analyze the impact on shareholders' welfare of delegating corporate governance to a board of directors who have the expertise to gather information about the firm. For tractability, we model a single representative risk-neutral director but address how our results extend to the case of multiple directors later in the paper (see Section 5.2).

The director perfectly learns β with some probability q. But she learns nothing about β with the remaining probability $(1-q)$. Acquiring precise information, i.e., high q, requires greater monitoring effort from the director, and the director is effort-averse. We represent the director's cost of information precision by a strictly increasing and strictly convex function, $C(q) = \frac{c}{2}q^2$, $c > 0$. However, we assume that the constant c is large enough, so that learning β with certainty is prohibitively costly for the director.

Shareholders cannot verify the director's choice of information precision q, and it is prohibitively costly for the director to communicate the results of the information generation—a complex and multidimensional inference on the firm's economic prospects—directly to the shareholders. Therefore, if the shareholders wish to exploit the director's information generation, they must delegate to the director the responsibility of designing the contract (δ).

Such delegation, however, presents another agency problem for the shareholders. There is a conflict of interest between the shareholders and the director because monitoring effort is personally costly for the latter. Moreover, from a

shareholder's perspective, any influence that the manager might have over the director will adversely affect her monitoring and contract design performance.

To capture the director's dependence on the manager, we assume that the director's welfare function is a weighted average of the manager's utility, with the weight $0 < \kappa < 1$, and the director's own expected wealth, with the weight $(1 - \kappa)$. A more dependent director derives a greater part of her utility from the manager's utility, i.e., has a higher weight, κ. We allow the shareholders to award the director an equity stake α in their share of the liquidating profits as incentive compensation. Since the director is risk-neutral, we can normalize any fixed-fee component of her compensation to zero. Thus, the director's utility U^D is

$$U^D = \kappa U^M + (1 - \kappa)\alpha V. \tag{7}$$

If $\kappa = 0$, the director's utility does not depend on the manager's utility, and the director is totally independent of the manager. On the other hand, if $\kappa = 1$, then the director is completely dependent on the manager.

By awarding equity incentives to the director (α), shareholders can influence the relative weights on the manager's utility, i.e., κ, and shareholder interests, i.e., $(1 - \kappa)\alpha$, in the director's utility function. We thus distinguish between the director's *intrinsic dependence*, given by κ, and her *effective independence*, given by $(1 - \kappa)\alpha$. Influencing the director's effective independence through equity awards (α) is costly for the shareholders, because their share of the liquidating profits is diluted from $(1 - \gamma)$ to $(1 - \alpha)(1 - \gamma)$ (cf. Equation (3)).

In equilibrium, shareholders choose between (i) delegating governance to the director with an equity award of α, or (ii) centralizing governance and contracting directly with the manager without any information generation regarding the productivity state (β). Our analysis will focus on the effect of the director's intrinsic dependence, κ, on the delegation decision, i.e., on the director's performance in her monitoring and contract design roles. The time line of informational events and decisions in the model is depicted in Figure 1.

2. Centralized Governance

In this section, we record some benchmark outcomes under alternative information and contractual assumptions. These benchmarks are useful in understanding the forces that drive our results. We begin with the complete information case where productivity is common knowledge and the manager's effort is costlessly verifiable. We then analyze the optimal mechanism design for the firm with asymmetric information under centralized governance.

2.1 Complete information

In the complete information case, there is no role for delegation. The optimal (or first-best) contract is denoted by $\delta_i^* = \langle \gamma_i^*, t_i^*, I_i^*, a_i^* \rangle$, $i \in \{L, H\}$. It is a

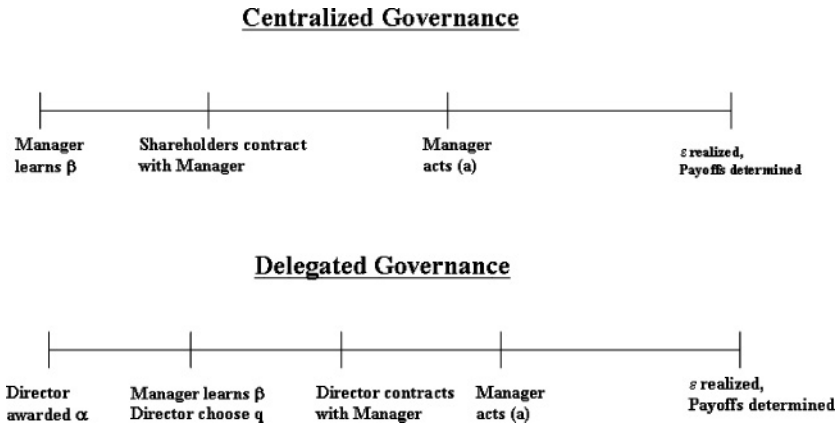

Figure 1
Model time-line
Under centralized governance, the manager learns the productivity parameter β before contracting with the shareholders. The manager's act a is unobservable, and the productivity shock ε has infinite support. Under decentralized governance, shareholders offer an equity award of α to the manager. Director chooses the monitoring incentive q before contracting with the privately informed manager; the rest of the time line is the same as under centralized governance.

solution to the following constrained maximization problem:

$$\begin{aligned} &\max_{\delta} \; pV_H + (1-p)V_L, \qquad \text{s.t.,} \\ &U_i^M \geq \overline{U}, \qquad i = L, H. \end{aligned} \tag{IR-FB}$$

Because the individual rationality constraints (IR-FB) will be binding for each productivity type, we can solve this problem directly by incorporating the constraints into the objective function. Using the expression for U^M from Equation (4), $t_i = \{\overline{U} - \phi I_i + \mu a_i - \gamma_i[\beta_i \log(I_i a_i) - I_i]\}/(1-\gamma_i)$, for $0 \leq \gamma_i < 1$. The optimal contract in productivity state i is

$$t_i^* = \overline{U} - \phi I_i^* + \mu a_i^*; \quad \gamma_i^* = 0; \quad I_i^* = \frac{\beta_i}{1-\phi}; \quad a_i^* = \frac{\beta_i}{\mu}, \quad i \in \{L, H\}. \tag{8}$$

The optimal investment and managerial effort are increasing in the firm's productivity. The optimal investment is also increasing in the manager's private benefit parameter (ϕ). The manager earns no rents in either productivity state. The manager receives greater private benefit in the high-productivity state because investment in this state is larger than the investment in the low-productivity state. However, the manager also receives lower monetary compensation in the high-productivity state compared to the low-productivity state.

For future reference, let $V_i^* = \beta_i \log(I_i^* a_i^*) - I_i^* - t_i^*$ denote the shareholders' expected payoffs in state $i = L, H$, in the first-best contract. Thus, the outside equity value in the first-best case is $V^* = pV_H^* + (1-p)V_L^*$.

2.2 Asymmetric information with centralized governance

To facilitate intuition in analyzing the generalized agency problem with both adverse selection and moral hazard at the level of the firm, we briefly consider the polar cases of pure adverse selection (where there is no hidden action) and pure moral hazard (where there is no hidden information). In the pure adverse selection case, the truth-telling constraints are satisfied by transfers to the manager that are not contingent on output, and therefore, the first-best outcome is achievable. Similarly, the first-best outcome is achievable with pure moral hazard if the agent is risk-neutral. In this case, the shareholders "sell" the firm to the manager at a type-contingent price that makes the agent indifferent to accepting or rejecting the offer (e.g., Harris and Raviv, 1979). Thus, the first-best expected payoff allocations are obtained under either pure adverse selection or pure moral hazard settings.

However, one cannot achieve the first-best arrangement when both moral hazard and adverse selection are present. Because of moral hazard, we cannot enforce the first-best by awarding noncontingent (or lump-sum) transfers to the manager. A non-performance-based transfer will induce only the minimal effort from the manager. Because of adverse selection, we cannot implement the first-best outcome by "selling" the firm, since the type of firm is unknown.

With generalized agency, the low-productivity manager has an incentive to mimic the high-productivity manager and to attract more investment. Moreover, both types of managers have an incentive to shirk, because effort is personally costly to them. Consequently, there will be some underinvestment (relative to the first-best level) in the high-productivity state to reduce the low-productivity manager's incentives to mimic. As well, it will be generally optimal to award equity-based compensation to the manager to motivate higher effort.

Specifically, the optimal contract designed by the shareholders in centralized governance ($\hat{\delta}$) is a solution to the following optimization problem:[7]

$$\begin{aligned} &\underset{\delta}{\text{Max}}\ pV_H + (1-p)V_L, \qquad \text{s.t.,} \\ &\quad U_i^M \geq \overline{U}, i = L, H, && \text{(IR-CG)} \\ &U_i^M \geq U_{ij}^M, i = L, H, j = H, L. && \text{(IC-CG)} \end{aligned}$$

Here, (IR-CG) and (IC-CG) are the individual rationality and truth-telling constraints, respectively. The optimal contract ($\hat{\delta}$) implements the first-best in the low-productivity state by prescribing the sale of the firm to the manager at a price that extracts his surplus. As indicated above, in the high-productivity state, $\hat{\delta}$ attempts to resolve the conflict between inducing truth-telling and ensuring obedience by awarding equity-based compensation to the manager, i.e., $1 > \widehat{\gamma}_H > 0$, and tolerating some underinvestment, i.e., $\widehat{I}_H < I_H^*$. In fact,

[7] Note that in this formulation, we combine the truth-telling and obedience constraints by using Equations (4) and (6), thereby forcing the effort to be incentive compatible for any type-contingent investment and compensation rule.

$(\widehat{I}_H, \widehat{\gamma}_H)$ are determined by the system of optimality conditions (see Appendix for the derivation)

$$\widehat{I}_H = \frac{\beta_H - \widehat{\gamma}_H(\beta_H - \beta_L)}{1-\phi}, \tag{9}$$

$$\frac{(1-\widehat{\gamma}_H)\beta_H}{\widehat{\gamma}_H} - \left\{ \begin{array}{c} (\beta_H - \beta_L)(\log(\widehat{I}_H) + \log(\widehat{\gamma}_H) - \log(\mu)) \\ -[\beta_H \log(\beta_H) - \beta_L \log(\beta_L)] \end{array} \right\} = 0. \tag{10}$$

We note that these optimal contract characteristics are obtained under the condition that the difference between productivities, $\Delta \equiv (\beta_H - \beta_L)$, is suitably bounded above. This condition merely places an upper bound on the extent of the adverse selection problem. Without this condition, the agency problem would be so severe that it would not be incentive-efficient to induce separation of types through underinvestment in the high-productivity state. For expositional ease, we will maintain the assumption that Δ is not too large.

Now, by construction, the optimal contract, $\hat{\delta}$, is the most efficient contract that the uninformed shareholders can design. It follows that an uninformed director cannot design a contract that is any more efficient than $\hat{\delta}$, even if the director were completely independent (i.e., $\kappa = 0$). This is because the uninformed director faces exactly the same contracting problem as the shareholders do. In general, a dependent director (i.e., with $\kappa > 0$) will design a contract that is suboptimal relative to $\hat{\delta}$, because the interests of such a director diverge from the shareholders' interests. Thus, $\hat{\delta}$ serves as a benchmark for evaluating the contracting performance of a dependent director.

Let $\hat{V}_i = (1-\widehat{\gamma}_i)[\beta_i \log(\widehat{I}_i \widehat{a}_i) - \widehat{I}_i - \widehat{t}_i]$ denote the outside equity value in productivity state $i = L, H$, under the optimal centralized governance contract, $\hat{\delta}$. The *maximal* outside equity value under centralized governance is therefore $V^C \equiv p_H \hat{V}_H + p_L \hat{V}_L$. We will use V^C as the benchmark for evaluating the optimality of delegating governance to the director.

3. Delegated Governance and Board's Independence

In the delegated governance regime, the director's monitoring effort and contracting efficiency together determine the shareholders' expected payoffs. In this section, we start by developing a necessary condition for delegation, in terms of α and κ, and then characterize their effects on the director's choice of monitoring effort and contract design. Finally, we endogenize the director's equity incentives (α) to obtain an overall perspective on the role of the director's dependence (κ) on shareholder value.

3.1 A necessary condition for delegation

In our model, the director is uninformed with probability $(1-q)$ and faces exactly the same generalized agency problem as the shareholders do under centralized governance. However, with probability q, the director faces a pure

moral hazard problem because she can perfectly infer the firm's productivity (β). But, and as we argue above, the first-best can be implemented in the pure moral hazard case by selling the firm to the manager at an appropriate price. Therefore, a necessary condition for delegation is that a perfectly informed director should implement the first-best, because there can be no gain from delegation if this condition is not satisfied.

Delegation will be optimal only if the director is not too dependent on the manager, because shareholders are constrained in their ability to influence the director through equity awards ($\alpha \leq 1$). We now derive a precise threshold level of the director's intrinsic dependence (κ) above which delegation cannot be optimal.

Proposition 1. *Delegation of governance to the director can be optimal only if* $\kappa \leq (1 - \kappa)\alpha$. *Hence, there is no delegation of governance to the director if* $\kappa > 1/2$.

The condition of Proposition 1 ensures that if the director is (perfectly) informed, then she will implement the first-best. In subsequent analysis, we assume that this condition holds, because it is not meaningful to consider delegated governance otherwise.

3.2 Optimal contract design by the director

In principle, the board is supposed to bargain with executives on investment and managerial compensation policies at arm's length, in the interests of the shareholders. But this arm's-length contracting view often does not apply in practice for at least two important reasons (see, e.g., Bebchuk and Fried, 2004). Directors are often dependent on managers, for the reasons we have discussed above. Our model addresses this aspect of the board's preferences through the intrinsic dependence parameter (k).

In addition, management's informational advantage over the directors substantially constrains the board's bargaining effectiveness vis-à-vis executives (Crystal, 1991; Main et al., 1995; and McGeehan, 2003). For example, Bebchuk and Fried (2004, p. 36) argue that "Even independent directors who for some reason wished to serve shareholders' interests in bargaining [with] the CEO . . . have usually lacked the time and information to do so."[8] Note that asymmetric information reduces the board's bargaining strength for any given level of director's dependence.

In our model, the manager's additional bargaining power due to asymmetric information results in a contract that is closer to his personal preference. This is because any efficient contractual (or bargaining) outcome maximizes a welfare

[8] The negative effect of the manager's private information on the board's bargaining position is, in fact, consistent with the bargaining literature. For example, Rubinstein's (1982, 1985) analysis of a sequential bargaining model shows that, compared to the symmetric information case, asymmetric information reduces the expected payoffs of the uninformed party, while improving the expected payoffs of the privately informed party.

function that is a weighted average of the utilities of the director and the manager, subject to the incentive compatibility constraints (see, e.g., Ausubel and Deneckere, 1989). Thus, if the director is fully informed (on β), then the director chooses the contract δ to maximize her utility, U^D (specified in Equation (7)). But if the director is uninformed, then it is as if she chooses δ by maximizing a welfare function with an enhanced weight on the manager's utility.

Specifically, there exists a parameter, $\theta > 1$, such that the uninformed director chooses δ to maximize the welfare function,

$$W \equiv \kappa\theta U^M + (1-\kappa)\alpha V, \tag{11}$$

subject to the individual rationality and the generalized agency incentive compatibility constraints. That is, the director's optimal contract, $\tilde{\delta}_i = \langle \tilde{\gamma}_i, \tilde{t}_i, \tilde{I}_i, \tilde{a}_i \rangle$, $i \in \{L, H\}$, solves the constrained maximization problem

$$\begin{aligned} \underset{\delta}{\text{Max}}\ & pW_H(\delta) + (1-p)W_L(\delta), \qquad \text{s.t.,} \\ & U_i^M \geq \overline{U}, i = L, H; && \text{(IR-DG)} \\ & U_i^M \geq U_{ij}^M, i = L, H, j = H, L, && \text{(IC-DG)} \end{aligned}$$

where $W_i(\delta) \equiv \kappa\theta U_i^M(\delta) + (1-\kappa)\alpha V_i(\delta)$.

Because the individual rationality and incentive compatibility constraints for the centralized governance contract design (i.e., (IR-CG) and (IC-CG)) are similar to the contract design by the uninformed director (i.e., (IR-DG) and (IC-DG)), $\tilde{\delta}$ has features that are qualitatively similar to $\hat{\delta}$. Notwithstanding the director's dependence, she still implements the first-best in the low-productivity state. In the high-productivity state, there is underinvestment relative to the first-best (i.e., $\tilde{I}_H < I_H^*$), and the manager receives equity-based compensation (i.e., $1 > \tilde{\gamma}_H > 0$). Finally, as with $\hat{\delta}$, the optimality of $\tilde{\delta}$ is subject to an upper bound on the extent of the adverse selection problem *ex ante*.

In the Appendix, we show that the optimality conditions corresponding to $(\tilde{I}_H, \tilde{\gamma}_H)$ are

$$\tilde{I}_H = \frac{\beta_H - \frac{(\alpha(1-\kappa)-\theta\kappa)}{\alpha(1-\kappa)}\tilde{\gamma}_H[\beta_H - \beta_L]}{1-\phi}, \tag{12}$$

$$\begin{aligned} &\frac{(1-\tilde{\gamma}_H)}{\tilde{\gamma}_H}\beta_H - \frac{[\alpha(1-\kappa)-\theta\kappa]}{(1-k)\alpha} \\ &\quad \times \left\{ \begin{matrix} [\beta_H - \beta_L](\log \tilde{I}_H) + \log(\tilde{\gamma}_H) - \log(\mu)) \\ -[\beta_H \log(\beta_H) - \beta_L \log(\beta_L)] \end{matrix} \right\} = 0. \end{aligned} \tag{13}$$

These conditions highlight the role of θ in the director's choice of $\tilde{\delta}$. Comparing Equation (12) with Equation (9), we find that, depending on θ, there can be under- or over-investment in the high-productivity state relative to the second-best investment, $\hat{I}_H$ (i.e., the optimal investment under centralized governance).

There is overinvestment if θ is sufficiently high, because the manager prefers higher investment and his ability to influence $\tilde{\delta}$ increases with θ.

A less dependent director will choose investment that is closer to the second-best. Indeed, we note from Equation (12) that $\tilde{I}_H$ approaches $\hat{I}_H$ as the director's dependence falls, i.e., κ approaches zero. However, the effect of the director's dependence on the manager's equity compensation, $\tilde{\gamma}_H$, is ambiguous. A more dependent director is inclined to increase the manager's equity compensation, other things held fixed. We call this the *managerial welfare effect*. However, if θ is large, then a more dependent director also increases $\tilde{I}_H$ (cf. Equation (12)) in order to benefit the manager's utility. But this increases investment inefficiency relative to the second-best and imposes a wealth cost on the director because of her equity ownership. To counteract this personal wealth effect, a more dependent director lowers the manager's equity compensation ($\tilde{\gamma}_H$). We call this the *investment cost effect*, which runs counter to the managerial welfare effect.

However, if θ is bounded, then the managerial welfare effect dominates the investment cost effect, and the director's dependence is positively related to $\tilde{\gamma}_H$.

Proposition 2. *Suppose that the manager's bargaining power over the uninformed director is bounded, i.e.,* $\theta \leq \frac{(1-\kappa)\alpha}{\kappa}$. *Then, the manager's equilibrium equity compensation* $\tilde{\gamma}_H$ *is strictly increasing in the director's dependence* (κ)*, and strictly decreasing in the director's equity ownership* α.

The bound on θ in Proposition 2 has an appealing economic interpretation because the ratio $[(1-\kappa)\alpha]/\kappa$ is the ratio of the director's effective independence to her intrinsic dependence. For a given κ, this ratio increases as a director receives greater equity ownership (α) in the firm.

Thus, equilibrium managerial compensation with delegated governance will be positively related to the director's dependence when the manager is constrained in leveraging his informational advantage over the director and when the span of the firm's investment returns is not too large. In these situations, the investment cost effect is likely to be small relative to the managerial welfare effect. But more generally, if the investment cost effect dominates the managerial welfare effect, then less dependent directors may optimally increase equity-based compensation for the manager.

We now examine the overall effect of a director's dependence on her contracting performance relative to the second-best. Let $\tilde{V}_i(\alpha, \kappa) = (1 - \tilde{\gamma}_i)[\beta_i \log(\tilde{I}_i \tilde{a}_i) - \tilde{I}_i - \tilde{t}_i]$ denote outside equity value in productivity state $i = L, H$, under the contract $\tilde{\delta}$.[9] Hence, $\tilde{V}(\alpha, \kappa) = p_L \tilde{V}_L(\alpha, \kappa) + p_H \tilde{V}_H(\alpha, \kappa)$ is the equilibrium outside equity value under asymmetric information when governance is delegated to a director with dependence, k.

[9] We suppress the implicit dependence of $\tilde{\delta}$ on θ for notational ease. We reiterate that $\tilde{V}_i(\alpha, \kappa)$ is allocated between the director—who gets a share α—and the shareholders who get the remaining share $(1 - \alpha)$.

A natural measure of contracting inefficiency under delegation is the difference $(V^C - \tilde{V}(\alpha, \kappa))$, where V^C is the maximal outside equity value under centralized governance (see Section 2.2). In particular, we can assess the (total) effect of the director's dependence on her contracting efficiency by examining the influence of (α, κ) on $\tilde{V}(\alpha, \kappa)$. A revealed preference-based intuition suggests that $\tilde{V}(\alpha, \kappa)$ will decrease the director's dependence (κ) and increase with her equity ownership (α). If the director has to bargain with the manager when the latter has an informational advantage, then a more dependent director will choose contracts that benefit the manager at the expense of the shareholders' interests, i.e., decreasing $\tilde{V}(\alpha, \kappa)$. Conversely, a director with greater equity ownership will place a higher weight on $\tilde{V}(\alpha, \kappa)$.

Proposition 3. *With delegated governance, the outside equity value under asymmetric information, $\tilde{V}(\alpha, \kappa)$, is decreasing in κ and increasing in α. Therefore, the director's contracting performance is negatively related to her dependence and positively related to her equity ownership, other things held fixed.*

An important implication of Proposition 3 is that if the director is uninformed, then her expected payoff from the firm—or equivalently, the value of her equity stake $\alpha\tilde{V}(\alpha, \kappa)$—is negatively related to her dependence. On the other hand, because managerial rents and outside equity value are in conflict, it follows from Proposition 3 that the manager's expected utility under $\tilde{\delta}$, $\tilde{U}^M(\alpha, \kappa)$ is increasing in κ and decreasing in α.

Note that Proposition 3 only relates the director's contracting performance to her dependence, conditional on the director being uninformed. But in our framework, the probability of being uninformed is itself under the control of the director through her choice of the monitoring effort (q). Similarly, the effect of the director's dependence can be ameliorated through higher equity awards to her. Therefore, Proposition 3 does not imply that board's performance improves as less dependent directors are chosen for the board.

A final assessment of the relationship between κ and the board's performance requires an analysis of how κ affects q, and how it influences the equity award to the director (α). We now turn to these tasks.

3.3 Optimal monitoring effort by the director

In this section, we analyze the optimal monitoring effort of the director. It turns out that both equity incentives and the director's dependence have ambiguous effects on the optimal monitoring effort. A less dependent director, or one with high equity ownership, may sometimes choose lower monitoring effort compared to a more dependent director, or one with low equity ownership. The reason for this ambiguity is that variations in (α, κ) have two conflicting effects on the director's benefits from monitoring at the margin.

Specifically, for a given (α, κ), the director's optimal monitoring effort, $q(\alpha, \kappa)$, maximizes

$$U^D(q, \alpha, \kappa) \equiv q \left\{ (1-\kappa)\alpha \sum_{i=L}^{H} p_i V_i^* + \kappa \overline{U} \right\} + (1-q) \left\{ \sum_{i=L}^{H} p_i \tilde{U}_i^D(\alpha, \kappa) \right\} - c\frac{q^2}{2}, \tag{14}$$

where $\tilde{U}_i^D(\alpha, \kappa) = \kappa \tilde{U}_i^M(\alpha, \kappa) + (1-\kappa)\alpha \tilde{V}_i(\alpha, \kappa)$ denotes the director's expected utility under $\tilde{\delta}$ in productivity state $i = L, H$. In Equation (14), we use the fact that the first-best shareholder value is attainable with probability q (cf. Proposition 1). The optimal monitoring effort is

$$q(\alpha, \kappa) = \max \left\{ 0, \frac{\sum_{i=L}^{H} p_i \left[(1-\kappa)\alpha \left(V_i^* - \tilde{V}_i(\alpha, \kappa) \right) - \kappa \tilde{U}_i^M(\alpha, \kappa) \right]}{c} \right\}. \tag{15}$$

From Equation (15), we can deduce that (α, κ) have two kinds of effects on the director's optimal monitoring effort—a direct incentive effect and an indirect wealth effect. There is a direct incentive effect because the director's benefit from being informed increases with her effective independence, $(1-\kappa)\alpha$. Notice that, for a given $(V^* - \tilde{V}(\alpha, \kappa))$, the director's utility gain from being informed is $(1-\kappa)\alpha(V^* - \tilde{V}(\alpha, \kappa))$—a quantity that increases in her effective independence. In addition, a less (intrinsically) dependent director gives lower weight to the manager's utility, which is represented by the second term in the numerator of Equation (15), and therefore stands to lose less from the manager's loss of information-based rents from monitoring. This incentive effect is consistent with the intuition that changing board composition by including less dependent directors, and awarding greater equity incentives to them, will increase the board's monitoring effort.

However, there is also an indirect wealth effect on the director's monitoring effort. Recall from Propositions 2 and 3 that the director's optimal contract design depends on the director's dependence and equity ownership. If the director is uninformed, then her contracting performance is negatively related to her dependence (κ) and positively related to her equity ownership (α). Consequently, the director's expected payoffs from the firm, i.e., $\alpha \tilde{V}(\alpha, \kappa)$, are lower when the director is more dependent or when she has lower equity ownership. To offset this adverse wealth effect, a more dependent director increases her monitoring effort (q) to reduce the likelihood of being uninformed, other things held fixed. Similarly, the wealth effect induces a director with lower equity ownership to increase her monitoring effort, other things being fixed.

Thus, the incentive and wealth effects of the director's dependence and equity ownership on her optimal monitoring effort are in conflict. As a result,

the relationship between the director's dependence and equity ownership on her optimal monitoring effort is generally ambiguous.

However, we can evaluate the relative strengths of these conflicting effects in terms of some model parameters. For example, the director's optimal monitoring effort is increasing in her equity ownership (α) if θ is close to 1. In other words, if the manager's bargaining power over the uninformed director is low, then the wealth effect is relatively weak, and the incentive effect dominates. But as θ moves farther away from one—or the manager's bargaining strength due to asymmetric information increases—the wealth effect becomes stronger and can overcome the incentive effect to produce a positive relationship between the director's monitoring effort and her dependence, and a negative relationship between her monitoring effort and her equity ownership.

It turns out that the indirect wealth effect also becomes weak as the "investment reward-to-risk" ratio β_H/Δ rises; recall that $\Delta = (\beta_H - \beta_L)$. The denominator of this ratio represents the adverse selection risk for outsiders (cf. Section 2.2), while its numerator represents the upside potential from investing in the firm. For firms with large investment reward-to-risk ratios, the director's optimal managerial contract ($\tilde{\delta}$) is not very sensitive to her dependence or her equity ownership. The incentive effect, therefore, dominates the opposing wealth effect. The director's optimal monitoring effort is therefore negatively related to her dependence and positively related to her equity ownership.

Proposition 4. *The effect of the director's dependence* (κ) *and equity ownership* (α) *on her optimal monitoring effort (i.e.,* $q(\alpha, \kappa)$*) is generally ambiguous. However, the director's optimal monitoring effort is increasing in her equity ownership and decreasing in her dependence if* θ *is sufficiently close to 1 or if the investment reward-to-risk ratio* (β_H/Δ) *is sufficiently large.*

It follows from the foregoing discussion that the relationship between the director's dependence, or equity ownership, and shareholders' expected payoffs is also ambiguous. Specifically, the shareholders' expected payoffs under delegated governance are

$$V^D(\alpha, \kappa) = (1 - \alpha)[q(\alpha, \kappa)V^* + (1 - q(\alpha, \kappa))\tilde{V}(\alpha, \kappa)]. \tag{16}$$

The effect of (α, κ) on $V^D(\alpha, \kappa)$ is ambiguous because of their ambiguous relationship with the director's optimal monitoring effort, $q(\alpha, \kappa)$.

3.4 Optimal equity incentives for the director

From the previous section, we know that the effect of equity incentives (α) on the director's monitoring effort is generally ambiguous. Now, the optimal α maximizes the outside shareholder value from delegation, $V^D(\alpha, \kappa)$ (cf. Equation (16)). In choosing the optimal equity incentives for the director, shareholders trade off the effects of equity ownership on the director's contracting

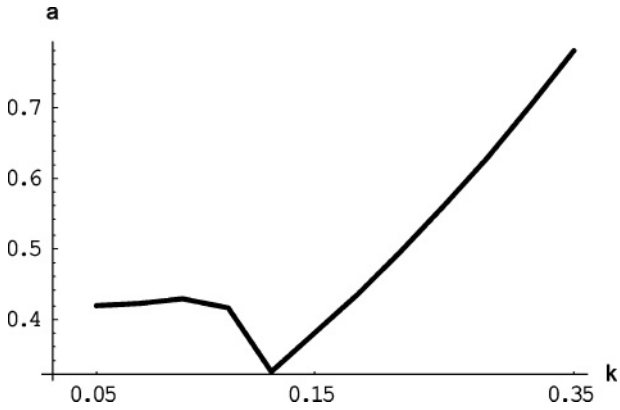

Figure 2
Optimal equity award
This figure presents a graph of the optimal equity award α to the director as a function of κ, the level of dependence of the director on the manager. For this example, the parameter values are set at $\beta_L = 14$, $\beta_H = 20$, $\phi = 0.10$, $\mu = 2$, $c = 2$, $p = 0.69$, $\bar{U} = 5$, $\theta = 1.5$.

performance (cf. Proposition 3) and monitoring effort (cf. Proposition 4) with the costs of cash flow ownership dilution.

Assuming interior solutions for q and α, the optimal equity incentive $\tilde{\alpha}(\kappa)$ satisfies

$$\Delta\tilde{V}(\alpha,\kappa)\left\{(1-\alpha)\frac{(1-\kappa)}{c}\Delta\tilde{V}(\alpha,\kappa)-q(\alpha,\kappa)\right\}$$
$$+(1-\alpha)(1-q(\alpha,\kappa))\frac{\partial\tilde{V}(\alpha,\kappa)}{\partial\alpha}-\tilde{V}(\alpha,\kappa)=0. \qquad (17)$$

The first two terms in Equation (17) capture the influence of equity incentives on the director's monitoring effort and contracting performance. The last term captures the cash flow dilution cost to the shareholders of providing higher equity ownership to the director.

Holding fixed the director's monitoring effort, as κ increases, i.e., the director is more dependent, the equity dilution cost falls because there is less value generated for the shareholders under delegation (cf. Proposition 3). This effect alone would lead to a positive association between $\tilde{\alpha}$ and κ, which would be consistent with the often advanced argument that more dependent directors require higher equity incentives (see, e.g., Byrne, 1996). However, as we know from Proposition 4, the relationship between the director's optimal monitoring effort (q) and her dependence (κ) is ambiguous. Therefore, the net effect of κ on $\tilde{\alpha}$ is also ambiguous.

Since the relation of the optimal α to κ is ambiguous, it is useful to work through a numerical example to gain some intuition.

In Figure 2, we present a graph of the optimal equity award to the director (α) as a function of the director's intrinsic dependence parameter (κ). In the chosen

parameterization, α, in fact, is nonmonotonic in κ. Beginning with complete independence, i.e., $\kappa = 0$, as the director's dependence on the manager initially increases, the optimal equity awards also increase. However, for a range of intermediate values of κ, the optimal equity awards to the director actually fall as the director becomes more dependent. We can attribute this behavior to the ambiguous effect of α on the director's optimal effort (cf. Proposition 4). In this region of κ, the payoffs from the director's improved monitoring incentives from increasing α are outweighed by the concomitant cash flow dilution cost to the shareholders. However, beyond a critical level of dependence, the optimal equity awards increase as the director becomes more dependent.

4. Optimal Governance Delegation and Director's Dependence

In this section, we present an overall perspective on the relation of the board's performance to intrinsic director's dependence (κ). While the foregoing analysis indicates that the relationship between a director's dependence and her monitoring and contracting performance is generally ambiguous, a question that remains is whether delegated governance can be optimal with dependent directors.

We compute shareholders' gain from delegation by comparing their expected payoffs, net of equity dilution costs, under delegation with their expected payoffs under centralized governance. In equilibrium, shareholder value under centralized governance is V^C (computed in Section 2.2), while the corresponding value under centralized governance is $\tilde{V}^D(\kappa) \equiv V^D(\tilde{\alpha}(\kappa), \kappa)$, as specified in Equation (16). The gain from delegation, expressed as a function of the director's dependence, is therefore $G(\kappa) \equiv \tilde{V}^D(\kappa) - V^C$. With judicious substitutions, this gain function is

$$G(\kappa) = \sum_{i=L}^{H} p_i\{(1-\tilde{\alpha})[q(\tilde{\alpha}, \kappa)V_i^* + (1 - q(\tilde{\alpha}, \kappa))\tilde{V}_i(\tilde{\alpha}, \kappa)] - \hat{V}_i\}. \tag{18}$$

To understand the relationship between κ and the gains from delegation, we compute

$$\frac{dG(\kappa)}{d\kappa} = (1-\tilde{\alpha})\sum_{i=L}^{H}\left\{p_i(1 - q(\tilde{\alpha}, \kappa))\frac{\partial \tilde{V}_i(\tilde{\alpha}, \kappa)}{\partial \kappa} + \frac{\partial q(\tilde{\alpha}, \kappa)}{\partial k}\left(V_i^* - \tilde{V}_i(\tilde{\alpha}, \kappa)\right)\right\}. \tag{19}$$

An increase in the director's dependence has two conflicting effects on $G(\kappa)$. Compared to less dependent directors, more dependent directors have poorer contracting performance, conditional on being uninformed (cf. Proposition 3). However, more dependent directors may put in greater monitoring effort than less dependent directors, as we discussed above. The overall relationship between director's dependence and outside shareholder value under delegation is thus ambiguous.

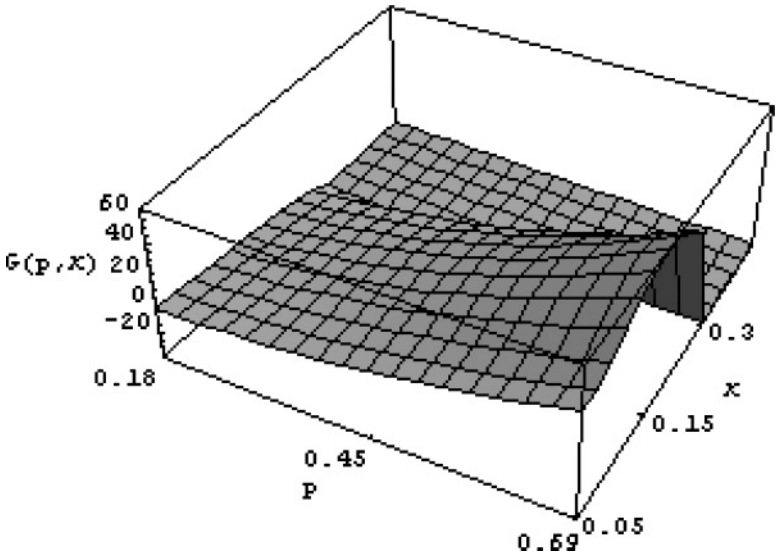

Figure 3
Gain from delegation
This figure presents a graph of the gain from delegation, $G(p, \kappa)$, as a function of p, the probability of high-productivity-type manager, and κ, the level of dependence of the director on the manager. For this example, the parameter values are set at $\beta_L = 14$, $\beta_H = 20$, $\phi = 0.05$, $\mu = 2$, $c = 2$, $\bar{U} = 5$, $\theta = 1.8$.

While we cannot generally derive a negative association between director's dependence and gains from delegation, we can examine the optimality of delegation in the "boundary case," where $\kappa \to 0$; i.e., the director is essentially independent. Now, delegating governance to an independent director is likely to be optimal if the agency costs with centralized governance are sufficiently high. The following result makes this intuition precise.

Proposition 5. *If the gains to the shareholders from delegating to an informed director are sufficiently high relative to centralized governance, i.e.,* $(V^* - V^C) > (cV^C)^{1/2}$*, then delegation is optimal when the director is sufficiently independent (i.e.,* $Lim_{k \longrightarrow 0} G(\kappa) > 0$*).*

With an independent director, the shareholders trade off the cost of dilution from awarding equity incentives to the director against the benefit from the monitoring effort of the director. $(V^* - V^C)$ is the expected gain to the shareholders from delegating to an informed director relative to centralized governance. Thus, the sufficient condition in Proposition 5 provides a lower bound on the gains from delegation to ensure that delegation is always optimal for directors who are sufficiently independent.

Because the overall relationship between the value from delegation and the director's dependence is generally ambiguous, it is useful to examine a numerical example. Figure 3 shows the gain from delegation, i.e., G, as a

function of the director's intrinsic dependence (κ) and the firm's expected capital productivity (p). Transparently, for any fixed p, the gain from delegation increases as κ initially increases from zero, i.e., the director is more intrinsically dependent. However, there exists a threshold level of the director's dependence above which the gain from delegation begins to fall sharply.

The board's performance initially improves with more dependent directors because they increase their monitoring effort to counteract the anticipated increase in contracting efficiency. The nonmonotonicity of G with respect to κ is especially pronounced for higher levels of p because expected contracting inefficiency costs increase with the likelihood of the high-productivity state. But as κ rises beyond a threshold level (which is about 0.3 in the chosen parameterization), the contracting efficiency costs dominate the improvement in monitoring effort, and the board's performance suffers overall.

We have emphasized above that the ambiguous relationship between director's dependence and board's performance would be more pronounced when θ is high. Indeed, we find that the nonmonotonicity of G with respect to κ is less pronounced as θ is lowered toward 1. This reiterates an important aspect of our analysis. Higher managerial bargaining power due to asymmetric information actually can induce superior performance from more dependent boards with equity ownership. If the directors realize that the manager can significantly amplify her bargaining power because of asymmetric information, and thereby lower the value of their equity stake in the firm, then they will attempt to offset the manager's informational advantage by improving their monitoring effort.

5. Extensions

5.1 The levered firm

The main results developed above extend also to the case where the firm is levered.[10] In brief, one important effect of introducing debt is that the marginal net benefit to the director of a higher monitoring effort declines as the firm gets more levered. This is because in a levered firm, the director's monitoring effort also benefits the debtholders; however, the director benefits from improved monitoring only as a residual claimant. This has consequences too for the relation of the optimal α to firm leverage. Holding other things fixed, an increase in leverage has two opposing effects. The marginal net benefit to the shareholders of more effective governance falls because bondholders gain from improved governance but do not directly share in the costs of improved governance, and this depresses α. But for a fixed α, the director's optimal monitoring effort input falls as leverage increases. To offset this effect, there is an incentive to increase α. Overall, the relation of the optimal α to leverage is therefore ambiguous.

[10] Details are available from the authors upon request.

5.2 The case of multiple directors

For analytical tractability, we have modeled and analyzed the agency conflicts among outside shareholders, managers, and directors from the viewpoint of a "representative" director. The results derived above would extend qualitatively in a noncooperative game to the case of multiple directors, with preferences or objectives similar to those of the typical director. Of course, with multiple directors, the set of possible equilibria can increase to include other equilibria because of the possibility of enforceable coalition formation and implicit coordination among directors. But the principal also can design communication mechanisms to exploit directors' common private information (see, e.g., Bernheim and Whinston, 1986; and Ma, Moore, and Turnbull, 1988). These are important issues for future research. However, our analysis provides one interesting implication for the impact of increasing board size on effective governance.

Suppose that there are N identical directors, with the same utility function as specified above. The important point here is that if each individual director is quasi-independent, then their individual utility functions still give a weight of κ to the manager's utility. Next, if the size of the total equity share given to the directors is α, then each director's individual equity share is α/N. Suppose that each individual director holds a veto over investment ratification and managerial contract design. Then, the necessary condition for delegation becomes

$$\frac{\alpha}{N} \geq \frac{\kappa}{1-\kappa}. \tag{20}$$

In this setting, the likelihood that delegated governance is optimal falls as board size increases, *ceteris paribus*. Of course, this negative-size effect on effective governance is only one aspect of a complex and rich delegation problem. In reality, there are likely to be offsetting effects attributable to improved information generation capabilities and other benefits from having multiple directors; otherwise, we would tend to observe only single-director boards—trivially, a counterfactual. This issue certainly deserves further attention in a fully specified model, but it is interesting that there is some empirical evidence documenting higher market valuation for smaller boards (see, e.g., Yermack, 1996).

6. Summary and Conclusions

Recent corporate governance reforms focus on board's independence and encourage equity ownership by directors. These reforms appear to assume that there is an unambiguous positive effect of board's independence and equity ownership on shareholder value. However, a careful modeling of the effects of director's independence and equity ownership on the monitoring intensity and contract design roles of the board shows that the board's performance can

actually worsen as board composition is altered to include directors that are less dependent on CEOs. With asymmetric information, more dependent directors perform relatively poorly in designing incentive-efficient contracts for the top management, and therefore achieve lower shareholder value. However, the poorer contracting performance imposes a personal wealth cost on directors if they hold equity in the firm. Thus, a more dependent director will optimally attempt to offset her expected wealth loss *ex post* by improving her monitoring effort *ex ante*, thereby increasing firm value. Therefore, the net effect on shareholder value of changing board composition to decrease the average level of director's dependence is also ambiguous.

Another interesting inference from our analysis is that higher equity incentives for the board need not constrain equity-based managerial compensation. Higher equity incentives for the board actually can increase the board's equity awards to managers. Consequently, the argument that more dependent directors require greater equity incentives need not apply generally. In fact, we present a numerical example in which the equilibrium relationship goes in the opposite direction.

Our modeling approach identifies important avenues for future research. For example, we assume that outside shareholders have the ability to negotiate optimally with asymmetrically informed executives. That assumption understates the value of delegated governance in our model. An avenue for future research is to model contracting under various organizational modes and to derive a more complete framework for analyzing optimal corporate governance. Another avenue is to consider the joint determination of debt and governance mechanisms, including equity incentives for directors, to clarify the effect of independence and other board characteristics on optimal capital structure.

Appendix

A. Derivation of the optimality conditions (9) and (10)

We start by conjecturing that only the (IR-CG) and (IC-CG) constraints with respect to the low-productivity type are binding and characterize the solution. We then confirm that only these two constraints are, in fact, binding in the solution. We also initially conjecture that $\gamma_j < 1$, for $j = L, H$ (i.e., the firm is not sold to the manager in either state), and then examine whether there is a corner solution. Now, let ω and η be the non-negative multipliers on the (IR-CG) and (IC-CG) constraints, respectively. With judicious substitutions, we can write the Lagrangian corresponding to the optimization problem associated with these constraints as

$$\begin{aligned}\$(\psi; p, \phi, \mu) = {} & p\{(1-\gamma_H)[\beta_H \log(I_H a_H(\psi)) - I_H - t_H]\} \\ & + (1-p)\{(1-\gamma_L)[\beta_L \log(I_L a_L(\psi)) - I_L - t_L]\}\end{aligned}$$

$$+\omega[\overline{U}-\gamma_L[\beta_L\log(I_La_L(\psi))-I_L-t_L]-t_L-\phi I_L+\mu a_L(\psi)]$$
$$+\eta\begin{pmatrix}\gamma_H[\beta_L\log(I_Ha_{L,H}(\psi))-I_H-t_H]+t_H+\phi I_H-\mu a_{L,H}(\psi)\\ -\gamma_L[\beta_L\log(I_La_L(\psi))-I_L-t_L]-t_L-\phi I_L+\mu a_L(\psi)\end{pmatrix},$$

where $a_{ij}(\psi)$ is given by Equation (6). The adjoint condition for I_L is

$$(1-p)(1-\gamma_L)\left[\frac{\beta_L}{I_L}-1\right]-(\eta+\omega)\gamma_L\left[\frac{\beta_L}{I_L}-1\right]-(\eta+\omega)\phi=0.$$

The adjoint condition for t_L is

$$-(1-p)(1-\gamma_L)+\omega\gamma_L-\omega+\eta\gamma_L-\eta=0$$
$$\Longrightarrow(1-p)(1-\gamma_L)+(\eta+\omega)(1-\gamma_L)=0.$$

The adjoint condition for t_H is

$$-p(1-\gamma_H)-\eta\gamma_H+\eta=0,$$

which yields $\eta=p$ or $\gamma_H=1$ (or both). We will conjecture that $\eta=p$ and show later that $\gamma_H<1$. Referring to the adjoint condition for t_L above, this implies that $(\eta+\omega)\geq p>0$. Therefore, it must be the case that $\gamma_L=1$, or the firm is sold to the manager in the low-productivity state at a price $t_L=-V_L^*$, and the low-productivity manager will implement $I_L=\frac{\beta_L}{1-\phi}$.

The adjoint condition for I_H is (noting that $\eta=p$)

$$\frac{\partial\$}{\partial I_H}=p(1-\gamma_H)\left[\frac{\beta_H}{I_H}-1\right]+\eta\gamma_H\left[\frac{\beta_L}{I_H}-1\right]+\eta\phi$$
$$=p(1-\gamma_H)\left[\frac{\beta_H}{I_H}-1\right]+p\gamma_H\left[\frac{\beta_L}{I_H}-1\right]+p\phi=0. \qquad \text{(A1)}$$

Thus, we have

$$I_H=\frac{\beta_H-\gamma_H[\beta_H-\beta_L]}{1-\phi}, \qquad \text{(A2)}$$

which yields (9). From Equation (A1), the second-order condition for I_H is

$$\frac{\partial^2\$}{\partial I_H^2}=-\frac{p}{I_H^2}[\beta_H-\gamma_H(\beta_H-\beta_L)]<0. \qquad \text{(A3)}$$

The last inequality follows because $\beta_H-\gamma_H(\beta_H-\beta_L)>0$. The adjoint condition for γ_H is (noting that $\eta=p$ and substituting appropriate values for $a_{i,j}(\psi)$)

$$\frac{\partial\$}{\partial\gamma_H}=p\frac{(1-\gamma_H)}{\gamma_H}\beta_H-p[\beta_H\log(I_Ha_H(\psi))-I_H-t_H]$$
$$+p[\beta_L\log(I_Ha_{L,H}(\psi))-I_H-t_H]$$

$$= p\frac{(1-\gamma_H)}{\gamma_H}\beta_H - p(\beta_H - \beta_L)[\log(I_H) + \log(\gamma_H) - \log(\mu)]$$
$$- p[\beta_H \log(\beta_H) - \beta_L \log(\beta_L)] = 0, \tag{A4}$$

which yields (10). The second-order condition for γ_H is

$$\frac{\partial^2 \$}{\partial \gamma_H^2} = -\frac{p}{\gamma_H^2}[\beta_H - \gamma_H(\beta_H - \beta_L)] < 0. \tag{A5}$$

Evaluating the left-hand side of Equation (A4) at $\gamma_H = 0$, $\frac{\partial \$}{\partial \gamma_H}|_{\gamma_H=0} = +\infty$, because $(\beta_H - \beta_L) > 0$. And evaluating the left-hand side of Equation (A4) at $\gamma_H = 1$,

$$\left.\frac{\partial \$}{\partial \gamma_H}\right|_{\gamma_H=1} = -(\beta_H - \beta_L)[\log(I_H) - \log(\mu)]$$
$$- [\beta_H \log(\beta_H) - \beta_L \log(\beta_L)] < 0.$$

The last inequality follows from the adjoint condition for γ_H above. Thus, $\gamma_H < 1$, which confirms our original conjecture that $\eta = p$ and $\gamma_H < 1$. Finally, it can be shown that the IR and IC constraints for the high-productivity type do not bind, provided $\beta_H - \beta_L \leq \Delta^*$, for some $\Delta^* > 0$ (proof omitted). ■

B. Proof of Proposition 1

Suppose that the director is informed of β. Then, she faces only the pure moral hazard problem. But due to risk-neutrality, the director can implement the complete information arrangement by selling the firm to the manager at a price that maximizes the director's utility; i.e., she chooses δ to maximize

$$U_j^D(\delta) \equiv \kappa U_j^M(\delta) + (1-\kappa)\alpha V_j(\delta), \qquad \text{s.t.}, U_j^M(\delta) \geq \overline{U},$$

where $V_j(\delta)$ and $U_j^M(\delta)[\equiv U_{jj}^M(\delta)]$ and are given by Equations (3) and (4), respectively. Let υ_j be the price for the firm in productivity state $j = L, H$. Straightforward computations indicate that if the firm is sold to the manager at the price υ_j (to be shared by the existing shareholders), then

$$\frac{\partial U_j^D}{\partial \upsilon_j} \propto -\kappa + (1-\kappa)\alpha. \tag{B1}$$

Thus, the director will implement the optimal (or second-best) pure moral hazard arrangement only if

$$\alpha \geq \frac{\kappa}{1-\kappa}. \tag{B2}$$

(Here, we make the usual convention that the director will act on the behalf of the shareholders when indifferent.) Hence, delegation can never be optimal

if $\alpha < \kappa/(1-\kappa)$. Finally, since $\alpha \leq 1$, Equation (B2) can never be satisfied if $\kappa > \frac{1}{2}$. ■

C. Proof of Proposition 2

The contract $\tilde{\delta}$ maximizes the objective function $W \equiv \sum_{j=L}^{H} p_j[\kappa\theta U_j^M + (1-\kappa)\alpha V_j]$, subject to the individual rationality (IR) and incentive compatibility (IC) constraints: $U_j^M(\psi_i) \geq \overline{U}$, $j = L, H$; and, $U_j^M(\psi_j) \geq U_{ji}^M(\psi_i)$, $i = L, H$, $j = H, L$. It can be shown that the IR and IC constraints for the high-productivity type do not bind, provided $\beta_H - \beta_L \leq \Delta^*$, for some $\Delta^* > 0$ (proof omitted). Then, $\tilde{\delta}$ maximizes the Lagrangian

$$
\begin{aligned}
&F(\psi; p, \phi, \mu) \\
&\quad = \sum_{j=L}^{H} p_j \begin{Bmatrix} \theta\kappa[\gamma_j[\beta_j \log(I_j a_j(\psi)) - I_j - t_j] + t_j + \phi I_j - \mu a_j(\psi)] \\ +(1-\kappa)\alpha(1-\gamma_j)[\beta_j \log(I_j a_j(\psi)) - I_j - t_j] \end{Bmatrix} \\
&\quad - \omega[\overline{U} - \gamma_L[\beta_L \log(I_L a_L(\psi)) - I_L - t_L] - t_L - \phi I_L + \mu a_L(\psi)] \\
&\quad - \eta \begin{pmatrix} \gamma_L[\beta_L \log(I_L a_L(\psi)) - I_L - t_L] + t_L + \phi I_L - \mu a_L(\psi) \\ -\gamma_H[\beta_L \log(I_H a_{L,H}(\psi)) - I_H - t_H] - t_H - \phi I_H + \mu a_{L,H}(\psi) \end{pmatrix}.
\end{aligned}
$$

Following along the lines similar to the derivation of (9) and (10) above, the adjoint conditions corresponding to I_H and γ_H are, respectively,

$$
\frac{dF}{dI_H} = p(1-\kappa)\alpha\left[\frac{\beta_H - \Phi\gamma_H\Delta\beta}{I_H} - (1-\phi)\right] = 0, \tag{C1}
$$

$$
\frac{dF}{d\gamma_H} = p(1-\kappa)\alpha\left[\frac{(1-\gamma_H)}{\gamma_H}\beta_H - \Phi\Psi\right] = 0, \tag{C2}
$$

where $\Phi = \frac{(\alpha(1-\kappa)-\theta\kappa)}{\alpha(1-\kappa)}$, and $\Psi = [\beta_H - \beta_L](\log(I_H) + \log(\gamma_H) - \log(\mu)) - [\beta_H \log(\beta_H) - \beta_L \log(\beta_L)]$. These adjoint conditions yield (12) and (13).

The second first-order condition yields $\Psi = \frac{(1-\gamma_H)\beta_H}{\gamma_H \Phi}$. Also, $\frac{d\Phi}{d\kappa} = -\frac{\theta}{\alpha(1-\kappa)^2}$, $\frac{dH}{dI_H} = \frac{\Delta\beta}{I_H}$, $\frac{dH}{d\gamma_H} = \frac{\Delta\beta}{\gamma_H}$.

Now,

$$
\begin{aligned}
\frac{dI_H}{dr} &= \frac{\frac{d^2F}{dI_H d\gamma_H}\frac{\partial}{\partial r}\left(\frac{dF}{d\gamma_H}\right) - \frac{d^2F}{d\gamma_H^2}\frac{\partial}{\partial r}\left(\frac{dF}{dI_H}\right)}{|J|}, \\
\frac{d\gamma_H}{dr} &= \frac{\frac{d^2F}{dI_H d\gamma_H}\frac{\partial}{\partial r}\left(\frac{dF}{dI_H}\right) - \frac{d^2F}{dI_H^2}\frac{\partial}{\partial r}\left(\frac{dF}{d\gamma_H}\right)}{|J|},
\end{aligned} \tag{C3}
$$

where

$$
|J| = \frac{d^2F}{d\gamma_H^2}\frac{d^2F}{dI_H^2} - \left(\frac{d^2F}{dI_H d\gamma_H}\right)^2
$$

$$\propto [\beta_H + \Phi\gamma_H\Delta\beta][\beta_H - \Phi\gamma_H\Delta\beta] - (\Phi\gamma_H\Delta\beta)^2.$$

Notice that $|J| > 0$ if $\beta_H^2 > 2(\Phi\gamma_H\Delta\beta)^2$. Next, we can show that

$$\frac{d^2F}{dI_H d\gamma_H} = -p(1-\kappa)\alpha\Phi\left[\frac{\Delta\beta}{I_H}\right], \frac{d^2F}{d\gamma_H^2} = -\frac{p(1-\kappa)\alpha}{(\gamma_H)^2}[\beta_H + \Phi\gamma_H\Delta\beta],$$
$$\frac{d^2F}{dI_H^2} = -p(1-\kappa)\alpha\left[\frac{\beta_H - \Phi\gamma_H\Delta\beta}{(I_H)^2}\right].$$

Let us first look at the parameter κ. Then,

$$\frac{\partial}{\partial\kappa}\left(\frac{dF}{d\gamma_H}\right) = -p(1-k)\alpha\Psi\frac{d\Phi}{d\kappa} = \frac{p\theta\Psi}{(1-\kappa)} = \frac{p\theta(1-\gamma_H)\beta_H}{(1-\kappa)\gamma_H\Phi}, \text{ and}$$
$$\frac{\partial}{\partial\kappa}\left(\frac{dF}{dI_H}\right) = -\frac{p(1-\kappa)\alpha\gamma_H\Delta\beta}{I_H}\frac{d\Phi}{d\kappa} = \frac{p\gamma_H\theta\Delta\beta}{I_H(1-\kappa)}.$$

Substituting for these expressions in Equation (C3), and with some algebra, we can show that $\frac{d\gamma_H}{d\kappa} > 0$, if

$$-\frac{p^2\alpha\theta}{(I_H)^2}[\Phi\gamma_H(\Delta\beta)^2 - \frac{(1-\gamma_H)\beta_H}{\gamma_H\Phi}(\beta_H - \Phi\gamma_H\Delta\beta)] > 0. \qquad \text{(C4)}$$

Now, in the limit as $\Delta\beta \to 0$, Equation (C4) reduces to

$$\frac{p^2\alpha\theta(1-\gamma_H)\beta_H^2}{\gamma_H\Phi(I_H)^2} > 0,$$

as long as $\Phi \geq 0$ or $\theta \leq \frac{\alpha(1-\kappa)}{\kappa}$. By continuity, for every given κ, there exists some $\bar{\beta} > 0$, such that if $\frac{(\beta_H - \beta_L)}{\beta_H} \leq \bar{\beta}$, then the term inside the square parentheses in Equation (C4) is negative, and hence $\frac{d\gamma_H}{d\kappa} > 0$.

Let us next look at α. The following derivatives are useful:

$$\frac{d\Phi}{d\alpha} = \frac{\theta}{\alpha^2(1-\kappa)}, \frac{d\Psi}{dI_H} = \frac{\Delta\beta}{I_H}, \frac{d\Psi}{d\gamma_H} = \frac{\Delta\beta}{\gamma_H}.$$

Then,

$$\frac{\partial}{\partial\alpha}\left(\frac{dF}{d\gamma_H}\right) = -p(1-k)\alpha\Psi\frac{d\Phi}{d\alpha} = -\frac{p\Psi}{\alpha} = -\frac{p(1-\gamma_H)\theta\beta_H}{\alpha\gamma_H\Phi}, \text{ and}$$
$$\frac{\partial}{\partial\alpha}\left(\frac{dF}{dI_H}\right) = -\frac{p(1-\kappa)\alpha\gamma_H\Delta\beta}{I_H}\frac{d\Phi}{d\alpha} = -\frac{p\gamma_H\theta\Delta\beta}{I_H\alpha}.$$

Substituting for these expressions in Equation (C3), and proceeding as before, we can show that $\frac{d\gamma_H}{d\alpha} < 0$ if $\Delta\beta$ is of a small enough magnitude with $\theta \leq \frac{\alpha(1-\kappa)}{\kappa}$. ■

D. Proof of Proposition 3

We first examine the behavior of $\tilde{V}(\alpha, \kappa)$. Fix any two independence parameters κ, κ', such that $\kappa > \kappa'$. Let $\tilde{\delta}(z)$ be the optimal mechanism chosen by a director of type z, $z = \kappa, \kappa'$, to maximize $W \equiv \kappa\theta U^M + (1-\kappa)\alpha V$. For notational ease, we suppress α and put $\tilde{U}^M(z) \equiv \tilde{U}^M(\tilde{\delta}(z))$ and $\tilde{V}(z) \equiv \tilde{V}(\tilde{\delta}(z))$. Therefore, the value of the objective under $\tilde{\delta}(z)$ is $\tilde{W}(z) \equiv [z\theta\tilde{U}^M(z) + (1-z)\alpha\tilde{V}(z)]$, $z = \kappa, \kappa'$. Clearly, the mechanism $\tilde{\delta}(\kappa)$ belongs to the set of feasible mechanisms for the type κ' director and vice versa. Hence, the assumption that $\tilde{\delta}(z)$ is chosen by the director of type z implies that

$$\begin{aligned} \kappa\theta\tilde{U}^M(\kappa) + (1-\kappa)\alpha\tilde{V}(\kappa) &\geq \kappa\theta\tilde{U}^M(\kappa') + (1-\kappa)\alpha\tilde{V}(\kappa') \\ \kappa'\theta\tilde{U}^M(\kappa') + (1-\kappa')\alpha\tilde{V}(\kappa') &\geq \kappa'\theta\tilde{U}^M(\kappa) + (1-\kappa')\alpha\tilde{V}(\kappa). \end{aligned} \tag{D1}$$

Adding together the two conditions in Equation (D1) and rearranging terms yields

$$(\kappa - \kappa')[\theta(\tilde{U}^M(\kappa) - \tilde{U}^M(\kappa')) - \alpha(\tilde{V}(\kappa) - \tilde{V}(\kappa'))] \geq 0. \tag{D2}$$

Since $\kappa > \kappa'$ (i.e., the director is less independent), $\tilde{U}^M(\kappa) \geq \tilde{U}^M(\kappa')$. Hence, Equation (D2) implies that $\tilde{V}(\kappa) \leq \tilde{V}(\kappa')$, as $\alpha > 0$. We now prove that $\tilde{V}(\kappa) \neq \tilde{V}(\kappa')$. Suppose, to the contrary, that $\tilde{V}(\kappa) = \tilde{V}(\kappa')$. Then, Equation (D1) implies that $\tilde{U}^M(\kappa) \geq \tilde{U}^M(\kappa')$ and $\tilde{U}^M(\kappa') \geq \tilde{U}^M(\kappa)$, i.e., $U^M(\kappa) = \tilde{U}^M(\kappa')$. Thus, under the hypothesis, $\tilde{W}(\kappa) = \tilde{W}(\kappa')$. But from the envelope theorem, we have $\frac{d\tilde{W}(z)}{dz} = \theta\tilde{U}^M(z) - \alpha\tilde{V}(z)$. Direct substitution of the optimal quantities, $(\tilde{I}_j, \tilde{\gamma}_j, \tilde{t}_j)$, $j = L, H$, derived from maximizing $F(\psi; p, \phi, \mu)$ above (cf. Proposition 2) and using an analysis similar to that employed in deriving (9) and (10), shows that $\theta\tilde{U}^M(z) \neq \alpha\tilde{V}(z)$ when we pick any arbitrary $\kappa > \kappa'$. Hence, the hypothesis $\tilde{W}(\kappa) = \tilde{W}(\kappa')$ for $\kappa > \kappa$ that follows from the assumption $\tilde{V}(\kappa) = \tilde{V}(\kappa')$ is contradicted. We therefore conclude that $\tilde{V}(\kappa) < \tilde{V}(\kappa')$ whenever $\kappa > \kappa'$.

Next, we examine the relation of $\tilde{V}(\alpha, \kappa)$ to α, where we now suppress the κ. Then, take any two equity shares α, α', such that $\alpha > \alpha'$. Revealed preference arguments similar to that used in (D1) yield

$$\begin{aligned} \kappa\theta\tilde{U}^M(\alpha) + (1-\kappa)\alpha\tilde{V}(\alpha) &\geq \kappa\theta\tilde{U}^M(\alpha') + (1-\kappa)\alpha\tilde{V}(\alpha') \\ \kappa\theta\tilde{U}^M(\alpha') + (1-\kappa)\alpha'\tilde{V}(\alpha') &\geq \kappa\theta\tilde{U}^M(\alpha) + (1-\kappa)\alpha'\tilde{V}(\alpha). \end{aligned} \tag{D3}$$

Then, adding together the two conditions in Equation (D3) and rearranging terms, we have

$$\kappa\theta(\tilde{U}^M(\alpha) - \tilde{U}^M(\alpha')) + (1-\kappa)(\alpha - \alpha')(\tilde{V}(\alpha) - \tilde{V}(\alpha')) \geq 0. \tag{D4}$$

Now, *ceteris paribus*, $\tilde{U}^M(\alpha)$ is decreasing in α because a higher α increases the director's effective independence, $(1-\kappa)\alpha$. Thus, $\kappa\theta(\tilde{U}^M(\alpha) - \tilde{U}^M(\alpha')) < 0$ if $\alpha > \alpha'$. Hence, Equation (D4) implies that $\tilde{V}(\alpha) \geq \tilde{V}(\alpha')$ since $\kappa < 1$.

Furthermore, using the envelope theorem, $\frac{d\tilde{W}(\alpha)}{d\alpha} = (1-\kappa)\tilde{V}(\alpha) > 0$ on $0 < \alpha < 1$. Thus, using an argument similar to the one used above, $\tilde{V}(\alpha) \neq \tilde{V}(\alpha')$, implying thereby that $\tilde{V}(\alpha) > \tilde{V}(\alpha')$. ■

E. Proof of Proposition 4

Using the optimal monitoring effort function $q(\alpha, \kappa)$ given in Equation (15), we compute for $q(\alpha, \kappa) > 0$

$$\frac{\partial q(\alpha,\kappa)}{\partial \alpha} \propto \Bigg[(1-\kappa)\big(V_H^* - \tilde{V}_H(\alpha,\kappa)\big) - \Bigg\{(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial \alpha} + \kappa\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \alpha}\Bigg\}\Bigg]. \tag{E1}$$

From the foregoing analysis, we know that $V_H^* > \tilde{V}_H(\alpha, \kappa)$. Now, by the envelope theorem, $(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial \alpha} + \kappa\theta\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \alpha} = 0$. Since $\theta > 1$ and $\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \alpha} < 0$ (cf. Proposition 3), it follows that

$$(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial \alpha} + \kappa\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \alpha} > 0.$$

Hence, the sign of the expression inside the square parentheses in the right-hand side of Equation (E1) is ambiguous. Next, for $q(\alpha, \kappa) > 0$,

$$\frac{\partial q(\alpha,\kappa)}{\partial \kappa} \propto -\Bigg[\alpha\big(V_H^* - \tilde{V}_H(\alpha,\kappa)\big) + \tilde{U}_H^M(\alpha,\kappa) + (1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial \kappa} + \kappa\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \kappa}\Bigg]. \tag{E2}$$

Since $\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \kappa} > 0$ (cf. Proposition 3), a reapplication of the argument made above yields

$$(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial \kappa} + \kappa\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial \kappa} < 0.$$

Thus, the sign of the expression inside the square parentheses in the right-hand side of Equation (E2) is also ambiguous.

Next, for any $r = \alpha, \kappa$, and using the fact that $(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial r} + \kappa\theta\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial r} = 0$, we have

$$(1-\kappa)\alpha\frac{\partial \tilde{V}_H(\alpha,\kappa)}{\partial r} + \kappa\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial r} = -\frac{\partial \tilde{U}_H^M(\alpha,\kappa)}{\partial r}\kappa(\theta-1). \tag{E3}$$

Then, let us first examine the case where $r = \alpha$. Substituting Equation (E3) into Equation (E1) yields

$$\frac{\partial q(\alpha, \kappa)}{\partial \alpha} \propto [(1-\kappa)\big(V_H^* - \tilde{V}_H(\alpha, \kappa)\big) + \frac{\partial \tilde{U}_H^M(\alpha, \kappa)}{\partial \alpha}\kappa(\theta - 1)]. \tag{E4}$$

However,

$$\frac{\partial \tilde{U}_H^M(\alpha, \kappa)}{\partial \alpha} = \frac{\partial \tilde{\gamma}_H(\alpha, \kappa)}{\partial \alpha}[\beta_H \ln(\tilde{I}_H \tilde{a}_H) - \tilde{I}_H] + \frac{\partial \tilde{I}_H(\alpha, \kappa)}{\partial \alpha}\left[\left(\frac{\beta_H}{\tilde{I}_H} - 1\right) + \phi\right], \tag{E5}$$

where, from earlier analysis (cf. proof of Proposition 2), we can compute

$$\frac{\partial \tilde{\gamma}_H(\alpha, \kappa)}{\partial \alpha} \propto \frac{X\left(\frac{1}{\tilde{I}_H}\right)^2 \tilde{\gamma}_H + \frac{(1-\tilde{\gamma}_H)}{\tilde{\gamma}_H}\left[Y\left(\frac{\beta_H}{\Delta\beta \tilde{I}_H}\right)^2 - Z\left(\frac{1}{\tilde{I}_H}\right)^2\right]}{\left(\frac{\beta_H}{\Delta\beta}\right)^2 - 2(\Phi\gamma_H)^2}. \tag{E6}$$

Here, X, Y, and Z are well-defined functions of (α, κ, θ) which are taken as given for the analysis at hand. Now notice that, for a fixed $\Delta\beta (\equiv \beta_H - \beta_L)$,

$$\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} \left(\frac{\beta_H}{\Delta\beta \tilde{I}_H}\right) = \lim_{\beta_H \to \infty} \left(\frac{\frac{\beta_H}{\Delta\beta}(1-\phi)}{\frac{\beta_H}{\Delta\beta} - \frac{(\alpha(1-\kappa)-\theta\kappa)}{\alpha(1-\kappa)}\tilde{\gamma}_H}\right) = 1 - \phi. \tag{E7}$$

From the continuity of limits, it therefore also follows that $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} (\frac{\beta_H}{\Delta\beta \tilde{I}_H})^2 = (1-\phi)^2$. Also, we can show that $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} (\frac{1}{\tilde{I}_H})^2 = 0$; and $\lim_{\beta_H \to \infty} (\frac{1-\tilde{\gamma}_H}{\tilde{\gamma}_H})$ is finite, from the first-order condition (C2). Hence, we conclude from Equation (E6) that $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} \frac{\partial \tilde{\gamma}_H(\alpha, \kappa)}{\partial \alpha} = 0$. Next, we compute

$$\frac{\partial \tilde{I}_H(\alpha, \kappa)}{\partial \alpha} \propto \frac{X'\left(\frac{1}{\tilde{I}_H}\right)\frac{(1-\tilde{\gamma}_H)}{\tilde{\gamma}_H}\frac{\beta_H}{\Delta\beta} + Y'\left(\frac{\beta_H}{\Delta\beta \tilde{I}_H}\right)^2 - Z\left(\frac{1}{\tilde{I}_H}\right)^2}{\left(\frac{\beta_H}{\Delta\beta}\right)^2 - 2(\Phi\gamma_H)^2}, \tag{E8}$$

where again X' and Y' are well-defined functions of (α, κ, θ). Using L'Hopital's rule and basic laws of limits, it is straightforward to show that $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} \frac{\partial \tilde{I}_H(\alpha, \kappa)}{\partial \alpha} = 0$. Next, by assumption, $[\beta_H \ln(\tilde{I}_H \tilde{a}_H) - \tilde{I}_H]$, the expected profit in productivity state H is bounded for all $(\tilde{I}_H, \tilde{a}_H)$. Finally, $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} (\frac{\beta_H}{\tilde{I}_H} - (1-\phi)) = 0$ from Equation (E7). Putting all these facts together, we conclude from Equation (E5) that $\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} \frac{\partial \tilde{U}_H(\alpha, \kappa)}{\partial \alpha} = 0$. However, $V_H^* > \tilde{V}_H(\alpha, \kappa)$ for every β_H. Hence, it follows from Equation (E4) that

$$\lim_{\frac{\beta_H}{\Delta\beta} \to \infty} \frac{\partial q(\alpha, \kappa)}{\partial \alpha} > 0.$$

The calculations for $r = \kappa$ are similar. ■

F. Proof of Proposition 5

We compute the gain from delegation function $G(\cdot)$ in the limiting case $\kappa = 0$, keeping fixed some $\alpha > 0$. That is,

$$G(0;\alpha) = \sum_{j=L}^{H} p_j(1-\alpha)[q(\alpha,\kappa=0)V_j^* + (1-q(\alpha,\kappa=0))\tilde{V}_j(\alpha,\kappa=0)] - \hat{V}_j.$$

We note that Proposition 3 implies that $\lim_{k\longrightarrow 0}\tilde{V}_H(\alpha,\kappa=0) = \hat{V}_H$. (Recall that, $\tilde{V}_L = \hat{V}_L$, for all (α,κ).) Moreover, using Equation (15) above, we have

$$q(\alpha,\kappa=0) = \frac{p\alpha\big(V_H^* - \tilde{V}_H(\alpha,\kappa=0)\big)}{c} = \frac{p\alpha\big(V_H^* - \hat{V}_H\big)}{c}. \qquad \text{(F1)}$$

Substituting the annunciated expression for $q(\alpha,\kappa=0)$ from Equation (F1) and rearranging terms yields

$$G(0;\alpha) \propto \left[\frac{p^2(1-\alpha)\big(V_H^* - \hat{V}_H\big)^2}{c}\right] - \hat{V}_H.$$

Clearly, $G(0;\alpha=0) > 0$ if the condition stated in the proposition holds. Hence, for α positive and small, $G(0;\alpha) > 0$. The proposition then follows from the continuity of $G(\kappa)$. ■

References

Anand, S. 2005. Under New Rules, Investors Are Owed Some Explanations. *Wall Street Journal*, July 8, p. C1.

Ausubel, L., and R. Deneckere. 1989. A Direct Mechanism Characterization of Sequential Bargaining with One-Sided Incomplete Information. *Journal of Economic Theory* 48:18.

Bainbridge, S. 2002. A Critique of NYSE's Director Independence Listing Standards. Research Paper, UCLA School of Law.

Bebchuk, L., and J. Fried. 2004. *Pay Without Performance*. Cambridge, MA: Harvard University Press.

Bernheim, B., and M. Whinston. 1986. Common Agency. *Econometrica* 54:355–72.

Black, B. 2000. The Fiduciary Duties of Outside Directors. Working Paper, Stanford University.

Black, B., and S. Bhagat. 2002. The Non-Correlation Between Board Independence and Long-Term Firm Performance. *Journal of Corporation Law* 27:231–74.

Brickley, J., J. Coles, and R. Terry. 1994. The Board of Directors and the Enactment of Poison Pills. *Journal of Financial Economics* 35:371–90.

Byrne, J. 1996. The Best and Worst Boards. *Business Week*, November 25, pp. 82–91.

Conference Board. 2002. Directors' Compensation and Board Practices in 2002. Reseach Report. New York: Conference Board.

Crystal, G. 1991. *In Search of Excess: The Overcompensation of American Executives*. New York: W.W. Norton.

Faynzilberg, P., and P. Kumar. 1997. Optimal Contracting of Separable Production Technologies. *Games and Economic Behavior* 21:15–39.

Faynzilberg, P., and P. Kumar. 2000. On the Structure of the Generalized Principal-Agent Problem: Decomposition and Existence Results. *Review of Economic Design* 5:23–58.

Fitch, E., and L. White. 2001. Why Do CEOs Reciprocally Sit on Each Other's Boards? Working Paper, New York University.

Fluck, Z. 1998. Optimal Financial Contracting: Debt vs. Outside Equity. *Review of Financial Studies* 11:383–418.

Gabrielle, M. 2001. Outside Board Members Earning Record Sums. *CFO Magazine*, February.

Harris, M., and A. Raviv. 1979. Optimal Incentive Contracts with Imperfect Information. *Journal of Economic Theory* 20:231–60.

Harris, M., and A. Raviv. forthcoming. A Theory of Board Control and Size. *Review of Financial Studies*.

Hart, O. 1995. *Firm, Contracts, and Financial Structure*. London: Oxford University Press.

Hermalin, B., and M. Weisbach. 1998. Endogenously Chosen Boards of Directors and Their Monitoring of the CEO. *American Economic Review* 88:96–118.

Ma, C., J. Moore, and S. Turnbull. 1988. Stopping Agents from Cheating. *Journal of Economic Theory* 46:255–72.

Main, B., C. O'Reilly, and J. Wade. 1995. The CEO, the Board of Directors, and Executive Compensation: Economic and Psychological Perspectives. *Industrial and Corporate Change* 11:292–332.

McGeehan, P. 2003. What Is the Boss Making? *New York Times*, September 21, Sec. 3, p. 1.

Mills, C. 2000. *The Power Elite*. New York: Oxford University Press.

Morgensen, G. 2005. Charity Begins at the Board. *New York Times*, April 10.

Myers, S. 2000. Outside Equity. *Journal of Finance* 55:1005–37.

Myerson, R. 1982. Optimal Coordination Mechanisms in Generalized Principal-Agent Problems. *Journal of Mathematical Economics* 10:67–81.

Pearl Meyer & Partners. 2005. Director Compensation Report. New York. Available at http://www.pearlmeyer.com/resdir.html. Accessed June 7, 2006.

Rubinstein, A. 1982. Perfect Equilibrium in a Bargaining Model. *Econometrica* 50:97–109.

Rubinstein, A. 1985. A Bargaining Model with Incomplete Information about Time Preferences. *Econometrica* 53:1151–72.

Shivdasani, A., and D. Yermack. 1999. CEO Involvement in the Selection of New Board Members: An Empirical Analysis. *Journal of Finance* 54:1829–53.

Stulz, R. 1990. Managerial Discretion and Optimal Financing Policies. *Journal of Financial Economics* 26:3–27.

Van Den Berghe, L., and A. Levrau. 2004. Evaluating Boards of Directors: What Constitutes a Good Corporate Board? *Corporate Governance: An International Review* 12:461–78.

Yermack, D. 1996. Higher Market Valuation for Firms with a Small Board of Directors. *Journal of Financial Economics* 40:185–211.

Zajac, E., and J. Westphal. 1996. Who Shall Govern? CEO-Board Power and the Dynamics of Board Interlocks. *Administrative Science Quarterly* 41:507–29.