A Theory of Board Control and Size

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This article presents a model of optimal control of corporate boards of directors. We determine when one would expect inside *versus* outside directors to control the board, when the controlling party will delegate decision-making to the other party, the extent of communication between the parties, and the number of outside directors. We show that shareholders can sometimes be better off with an insider-controlled board. We derive endogenous relationships among profits, board control, and the number of outside directors that call into question the usual interpretation of some documented empirical regularities. (*JEL* G34)

Corporate governance, and in particular the issue of control of corporate boards by independent directors, has received considerable attention recently, in the wake of corporate scandals afflicting the likes of Enron, Tyco, Adelphi, and others.[1] In 2002, Congress passed the Sarbanes-Oxley Act mandating, among other requirements, that the audit committees of the boards of directors of firms listed on national exchanges have a majority of independent members. In 2003, both the New York Stock Exchange and NASD amended their rules to require the boards of listed firms to have a majority of independent members.[2] Meanwhile, the Securities and Exchange Commission recently changed its rules for mutual fund boards from requiring more than 50% independent directors to requiring at least 75% and requiring them to have an independent chairman.[3] Despite the attention given to this issue in the popular press, by Congress, and by the major stock exchanges, there has been little

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[1] See, for example,Burns (2004), Luchetti and Lublin (2004), and Solomon (2004).

[2] See New York Stock Exchange Rule 303A and NASD Rule 4350(c).

[3] In June 2005, however, the US Court of Appeals for the District of Columbia Circuit directed the SEC to reconsider this rule change.

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theoretical work on this topic.[4] This article attempts to contribute to filling that gap.

The developments mentioned in the previous paragraph suggest that the prevailing view among regulators is that it is in the interest of shareholders for corporate boards to be controlled by independent directors. This view seems to be driven by agency considerations, that is, that only independent directors (*outsiders*) can effectively curtail agency problems. Although agency problems are clearly important, other considerations may affect the conclusion that boards should be outsider-controlled. In particular, the board's decisions are based on the information available to its members, information provided both by insiders and by outsiders.[5] Since board control affects the strategic interaction between insiders and outsiders, it also affects the board's decisions and hence shareholder value. For example, when outsiders control the board, insiders may not provide full or completely accurate information. Obviously, this can have an adverse effect on the board's decisions, reducing shareholder value.

In this article, we take account of both the direct effects of agency problems on corporate decision-making and the indirect effects of agency problems on communication between insiders and outsiders. We model a board of directors that consists of insiders and (possibly) outsiders who must choose the size of an investment. Insiders have private information relevant to the decision but also have private benefits that lead them to choose a size that does not maximize profits. Outside directors seek to maximize firm profits (they perfectly represent the firm's owners) and may, at a cost, acquire private, decision-relevant expertise. Control of the board entitles the controlling party to make the decision themselves or delegate decision-making authority to the other party. The controlling party's delegation decision is based on its information. In addition, whoever makes the decision will base the decision on their own information and any information communicated to them by the other party. Because of the agency problem between insiders and outsiders, neither party will choose to communicate its information fully to the other.

We determine (i) optimal board control, (ii) when the controlling party will delegate decision-making authority to the other party, (iii) the extent of communication, (iv) the number of outside directors, and (v) firm profits. Despite the fact that the controlling party may delegate to the other, it still matters who controls the board for two reasons. First, who controls will affect the incentives of outsiders to acquire the necessary expertise in the firm's operations. Second, the delegation decision will

[4] One important exception that is related to this article is Hermalin and Weisbach (1998) which will be discussed below. Hermalin and Weisbach (2003) provide an excellent survey of economic research on boards of directors. As they point out, most of this work is empirical.

[5] This point has been noted by Adams and Feirrera (2003), discussed below. Grinstein and Tolkowsky (2004) document empirically the informational role of outsiders.

depend on the controlling party's information and will itself convey information. Whether outsiders or insiders optimally control the board is determined by comparing the two types of boards, taking account of the incentives of outsiders to acquire expertise, the likelihoods of the two parties to have decision-making authority, and the extent of communication as a function of who has this authority. We show, contrary to conventional wisdom, that despite the agency problem, it is sometimes optimal to have insiders in control of the board. This is partly because insider-control better exploits insiders' information. This will be especially valuable when insiders' information is important relative to the direct agency costs. In addition to exploiting insiders' information better, there is a more subtle argument for insider-control: when insiders are in control, they will not delegate to outsiders if outsiders are uninformed. When outsiders control the board, on the other hand, they can make decisions even when uninformed. Consequently, insider-control of the board may provide greater incentives for outsiders to become informed, thus increasing shareholder value.

The assumption that outside directors must exert effort to apply their expertise also allows us to determine the number of outsiders, along with board control, endogenously. The idea is simple. As the number of outsiders increases, their value to the company in providing expertise increases, provided each outsider continues to expend the same effort. But increasing their number aggravates a free-rider problem for outsiders. That is, when there are more outsiders, each outsider views the importance of his or her contribution as being reduced and, therefore, expends less effort in specializing his or her expertise. The optimal number of outsiders appropriately balances the two effects.

Since our model determines both the number of outside directors and profits endogenously, it has implications for the relationship between them. Moreover, we assume that the optimal number of insiders, given optimal board control, is determined by factors outside our model. With this assumption, given board control, the number of insiders is independent of the factors in our model that determine the number of outsiders. Consequently, board size and the *fraction* of outside directors will vary one-to-one with the *number* of outside directors. Thus, the model's implications about the relationship between profits and the number of outsider directors also apply to board size and the fraction of outsiders.

In our model, board size does not affect performance, but both are driven by other, exogenous factors, such as the importance of the various parties' information, profit potential, and the opportunity cost of outside directors. We show how certain movements in these factors can induce a negative correlation between profits and the number of outside board members. This can explain the observed negative correlation between profits and board size documented by Yermack (1996) and Eisenberg, Sundgren, and Wells

(1998), without any implication that large boards are less effective.[6] Our approach thus casts doubt on the interpretation of these authors that their evidence supports the hypothesis of Lipton and Lorsch (1992) and Jensen (1993) that large boards are less effective because of agency problems. Indeed, Hermalin and Weisbach (2003) ask why board size appears to affect performance and why we see so many large boards if, in fact, they are less effective than small boards. Our model can answer both questions.

Second, in our model, movements in the exogenous factors can induce a positive, negative, or no correlation between profits and the number of outsiders on the board. This may explain why many studies [see the survey by Hermalin and Weisbach (2003)] fail to find a correlation between performance and the fraction of independent directors (recall that the number and fraction of outsiders are positively correlated in our model).

Third, Rosenstein and Wyatt (1990) find "a positive stock price effect when an outsider is appointed to a company's board, even where outside directors already constitute a board majority" (Romano 1996). In our model, a firm will add an outside director only after a shock that increases the optimal number of outsiders. Such a shock, for example, a decrease in effort costs of outsiders, could also increase firm value. Thus it may be inappropriate to interpret the result as showing that increasing the number of outside directors improves performance. These three examples highlight the problem with interpreting empirical correlations as if the number of outside board members were exogenous.

Hermalin and Weisbach (1998) model a board's decision about whether to retain or replace the CEO. A number of interesting results are obtained regarding CEO compensation and turnover and the degree of independence of the board, but the model does not address the issue of the relation between the number of outside board members and contemporaneous profits or optimal board control. Raheja (2005) provides an alternative explanation to ours of the negative correlation between board size and performance that does not involve a causal relationship but does not emphasize delegation and communication as we do. Adams and Feirrera (2003) point out that to obtain better information from managers, the board may want to commit not to use this information in evaluating managerial performance.[7] Gillette, Noe, and Rebello (2003) show both theoretically and experimentally that when agency problems are especially severe, having even uninformed outsiders in control can prevent inefficient outcomes.[8]

[6] Similarly, Graham and Narasimhan (2004) show that "companies with large boards, and boards dominated by insiders are less likely to survive the Depression." (abstract).

[7] Spatt (2004) makes a similar point.

[8] Baranchuk and Dybvig (2005) also provide a model of boards of directors that, while quite different from ours, incorporates the idea that outside board members provide important information. Two other, less closely related, theoretical papers on corporate boards are Hirshleifer and Thakor (1994) and Warther (1998).

The remainder of this article is organized as follows. The model is described in section 1. In section 2, we analyze the delegation decision, the extent of communication, the incentives for outsiders to become informed, and the optimal number of outsiders for boards controlled by outsiders. In section 3, we do the same for boards controlled by insiders. We then compare outsider-controlled and insider-controlled boards to determine optimal board control in section 4. Section 5 presents some comparative statics results and their empirical predictions. Section 6 applies our model to the Sarbanes-Oxley Act, and section 7 concludes. Material of a mainly technical nature and many of the proofs are contained in a separate appendix, Harris and Raviv (2006).

1. The Model

We consider a firm whose profits depend on a strategic decision denoted s to be determined by the board of directors. For concreteness, we refer to this decision as the scale of an investment. Board members may be firm employees, whom we call insiders, or independent directors, whom we call outsiders. Either insiders or outsiders may control the board. Control of the board allows the controlling group to choose scale themselves or to delegate this decision to the other group.

The firm's optimal scale depends on private information of insiders ("agents"), $\tilde{a}$, and private information of outsiders ("principals"), $\tilde{p}$. In particular, profit, $\tilde{\pi}$, is given by

$$\tilde{\pi} = \pi_0 - [s - (\tilde{a} + \tilde{p})]^2. \tag{1}$$

Equation (1) implies that *potential profit*, π_0, is reduced to the extent that the scale is chosen to be other than the "first-best" scale, $\tilde{a} + \tilde{p}$. Chosen scale may differ from first-best for two reasons. First, the decision-maker will not have full information about either $\tilde{a}$ or $\tilde{p}$ or both. Second, an agency problem, to be introduced shortly, implies that insiders would not choose the first-best scale, even if they had full information. Consequently, we refer to the quadratic term in Equation (1), or its expectation, as the information-plus-agency cost. We assume that potential profit is sufficiently large that expected profit is always positive. This requires that $\pi_0 > \sigma_p^2 + b^2$, where σ_p^2 is the variance of $\tilde{p}$, and b is a parameter, to be introduced shortly, that measures the extent of the agency problem. Moreover, we assume that the compensation paid to outsiders is negligible compared with expected profits and is ignored when choosing the number of outsiders. Clearly, this assumption is appropriate only for large corporations.

We assume that insiders learn their information, $\tilde{a}$, in the course of their normal duties. Outsiders are presumed to have expertise about the other component of the optimal scale, which may include factors external to the firm. This expertise is costly to specialize to the firm's situation, however. Formally, we model this by assuming that, if any outsider invests noncontractible effort e at personal cost $c(e)$, he or she learns $\tilde{p}$ with probability e (we refer to this as "becoming informed"). Thus, the cost function should be interpreted as a measure of the uniqueness of the firm's activities, that is, the degree of difficulty of adapting general business lessons to this particular firm. Outsiders are assumed to have identical interests and therefore will share any information they produce among themselves (but cannot enter into contracts with each other, e.g., to compensate each other for investing effort in becoming informed). As a result, if at least one outsider becomes informed, this information can be used to choose scale.[9] The outsiders' information cannot be obtained by insiders, but may be communicated to them by outsiders. Similarly, outsiders cannot obtain the insiders' information directly, but insiders may communicate it to them. The extent to which one party will communicate its information to the other is limited by an agency problem which we now describe.

All board members are risk-neutral. Insiders have an equity stake and obtain a private benefit from larger scale. Specifically, we assume the combined effect results in a payoff to insiders given by[10]

$$\tilde{\pi}_I = \pi_{I_0} - [s - (\tilde{a} + \tilde{p} + b)]^2. \tag{2}$$

Note that the optimal scale from the point of view of insiders, given $\tilde{a}$ and $\tilde{p}$, is $\tilde{a} + \tilde{p} + b$. The parameter $b > 0$ measures the extent to which insiders prefer larger scale at the expense of profits. Because of the quadratic cost functions in Equations (1) and (2), the difference between the profits that result when the insiders choose scale and maximal profit, for any given information, is b^2. We therefore refer to b^2 (and sometimes b) as the *agency cost*.

We assume that outsiders' compensation consists entirely of an equity stake that is independent of outsiders' effort, since effort is assumed to be noncontractible.[11] Consequently, outsiders prefer the profit-maximizing scale. We denote by $\alpha \in (0,1)$ the share of equity given to each outside

[9] The purpose of these assumptions is to create a tradeoff in which more outsiders leads to greater information production, holding their effort constant, but also leads them to reduce effort, other things equal. The structure we have assumed leads to a fairly simple determination of the optimal number of outsiders, but we believe that the results would not be affected if we assumed any structure that embodies this tradeoff.

[10] The constant π_{I0} in Equation (2) can be different from potential profit to allow insiders' preferences to diverge from profits in addition to their preference for larger scale. This constant plays no role in the analysis.

[11] We could also include a salary without affecting the results. Our assumption is in line with Yermack (2004) that estimates that outside directors receive, on average, 11 cents for each $1000 increase in firm value.

board member. Outsiders' equity stake is determined by a participation constraint,

$$\alpha\pi - c(e) = \overline{U}, \tag{3}$$

where π is expected profit, and $\overline{U} > 0$ represents the value of an outside board member's opportunity cost of serving on the board.

We make the following assumptions regarding the distributions of $\tilde{a}$ and $\tilde{p}$:

Assumption 1. *The variables $\tilde{a}$ and $\tilde{p}$ are independent with $\tilde{a}$ uniformly distributed on [0,A] and $\tilde{p}$ uniformly distributed on [0,P].*

In some cases, it will be more convenient to work with the standard deviations of the random variables $\tilde{a}$ and $\tilde{p}$, as well as those of other uniformly distributed random variables, instead of the parameters A and P. Consequently, for any $x \geq 0$, denote by $\sigma(x)$ the standard deviation of a random variable uniformly distributed on an interval of width x, that is, $\sigma(x) = x/\sqrt{12}$. We will use σ_a to denote $\sigma(A)$ and σ_p to denote $\sigma(P)$.

Because of the quadratic cost function in Equation (1), it turns out that if an unbiased decision-maker chooses scale, the difference in profits between knowing $\tilde{p}$ ($\tilde{a}$) and having no information about $\tilde{p}$ ($\tilde{a}$) is exactly σ_p^2 (σ_a^2). We will therefore refer to σ_p^2 (σ_a^2) as the *full value of the outsiders' (insiders') information*. Many of our results depend on a comparison between agency costs and the value of one (or both) party's information. Accordingly, we refer to a firm for which (i) $b \geq \sigma_p$ ($b \geq \sigma_a$) as one for which *agency costs are more important than outsiders' (insiders') information*, (ii) $b \geq \max\{\sigma_a,\sigma_p\}$ as one for which agency costs are critical, (iii) $b \geq \min\{\sigma_a,\sigma_p\}$ as one for which *agency costs are important*, and (iv) $b < \min\{\sigma_a,\sigma_p\}$ as one for which *information is more important than agency costs*. This terminology is illustrated in Figure 1.

2. Outsider-Controlled Boards

We begin by analyzing the scale and delegation decisions of boards that are controlled by the outside directors. We refer to such a board as an outsider-controlled board (OCB). In this article, we assume that board control can be determined independently of the number of outsiders or insiders on the board. For example, even if there are more insiders than outsiders, outsiders may control key committees, or they may be explicitly given control over the kinds of decisions we model here, or overruling outsiders may require a supermajority of directors.[12]

[12] Romano (1996, n. 13) states that "The literature conventionally uses the terms outsider-dominated and insider-dominated to describe a board with a majority of outside directors and inside directors, respectively, and that convention will be adopted [in her paper]..., even though it is not, in my view, an apt

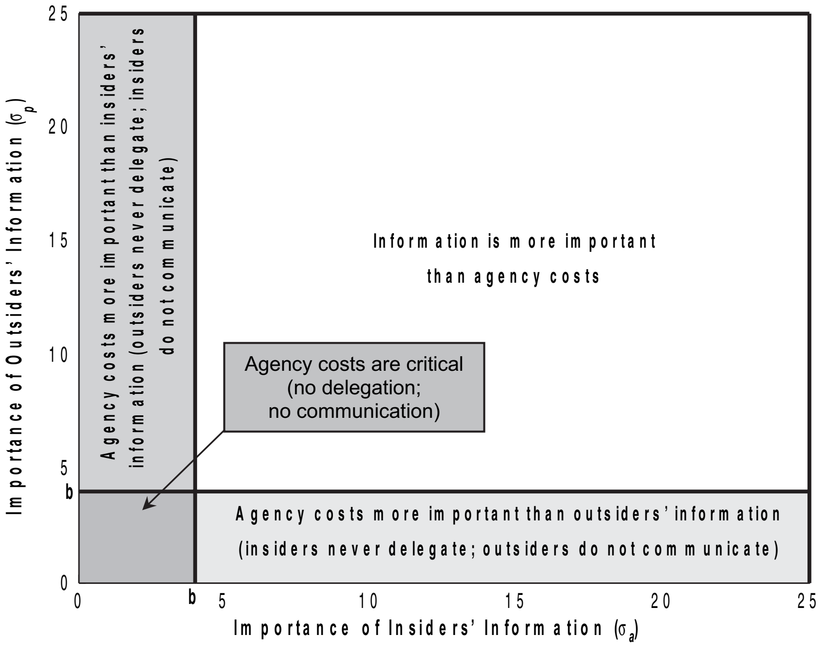

Figure 1
The relative importance of agency costs and information
This graph shows the definitions of the terms "Agency costs are more important than insiders' (outsiders') information," $b \geq \sigma_a(\sigma_p)$, "Agency costs are critical," $b \geq \max\{\sigma_a,\sigma_p\}$, and "Information is more important than agency costs," $b < \min\{\sigma_a,\sigma_p\}$.

Recall that outsider control of the board empowers the outside directors to choose scale or to delegate the choice of scale to insiders. If they do not delegate, they will choose scale based on their own information and any information communicated to them by insiders.[13] Denote by $r(a)$ the report of insiders to outsiders if insiders observe $\tilde{a} = a$. If outsiders delegate, insiders will choose scale based on their own information and any information communicated to them by outsiders. Denote by $t(p)$ the report of outsiders to insiders if outsiders observe $\tilde{p} = p$. Of course, outsiders will have nothing to report if they do not become informed.

expression because 'domination' of a board's decisions is likely to be a complex function of individual personalities and expertise rather than a function of the number of directors of a specific type."

[13] We do not consider the possibility of constrained delegation, that is, that one party allows the other party to choose s subject to a constraint. One can show, for example, that if the outsiders have no private information, it is optimal for them, when they delegate to insiders, to put an upper bound on insiders' choice that is sometimes binding. When outsiders have private information, the problem is more complicated, since their choice of a constraint may convey information. Since this model is sufficiently complicated already, we leave this possibility for future work.

Moreover, because of the agency problem, the reports will not fully communicate the reporting party's information, as will be seen below.

The sequence of events in this case is assumed to be the following. First, each outsider simultaneously chooses how much effort to invest in becoming informed. Next, either they become informed (i.e., at least one of them becomes informed) or they do not and then decide whether to delegate the scale decision to insiders. It will be shown below that if outsiders learn that $\tilde{p} = p$, they will delegate if and only if $p \geq p^*$, for some cutoff p^*. If outsiders fail to become informed, they will delegate the scale decision to insiders, unless agency cost is sufficiently large (how large is sufficient will be determined below).[14] Finally, depending on whether outsiders delegate or not, either insiders or outsiders choose scale and profits are realized. We start by analyzing the scale choice, given a delegation decision, then return to the delegation decision.

2.1 Outsiders do not delegate

Suppose outsiders choose scale themselves. Since they have identical preferences and information, outsiders behave as a single agent. Given their compensation, outsiders will maximize expected profits. It is easy to check that if outsiders are informed, they will choose

$$s(p,r) = \bar{a}(r) + p, \tag{4}$$

where $\bar{a}(r) = E(\tilde{a}|r)$, and the expectation is with respect to outsiders' posterior belief about $\tilde{a}$, given the insiders' report, r.

The game in which outsiders choose s is analyzed formally in Harris and Raviv (2005). There it is shown that, because of the agency problem, insiders will not fully reveal their information. More precisely, in the Pareto-best Bayes equilibrium of the game in which outsiders choose s, insiders will partition the support of $\tilde{a}$, $[0,A]$, into cells $[a_i,a_{i+1}]$ (of unequal widths) and report a value that is uniformly distributed on the cell in which the true realization of $\tilde{a}$ lies. Thus outsiders learn only the cell in which the true value of insiders' information lies, and their posterior belief is that $\tilde{a}$ is uniformly distributed on that cell. It follows that if the report r is in $[a_i,a_{i+1}]$, $\bar{a}(r) = (a_i + a_{i+1})/2$. The number of cells is denoted by $N(b,A)$ [see Harris and Raviv (2005) for an explicit formula]. Note that the number of cells is a measure of the extent to which insiders communicate their information to outsiders. For example, if there is only one cell, $N(b,A) = 1$, insiders communicate nothing outsiders do not already know. On the other hand, as $N(b,A)$ gets very large (as will be the case if agency cost, b, approaches zero), the information communicated approaches perfect information about $\tilde{a}$. It is easy to show that the

[14] This is also shown in Dessein (2002).

width of the partition cells, $a_{i+1} - a_i$, increases by $4b$ for each unit increase in i. That is, larger as result in larger reported intervals, so the reports contain less information. Intuitively, since outsiders know that insiders are biased toward larger scale, insiders are less believable the larger is the reported value of $\tilde{a}$.

If outsiders are not informed, they will choose

$$s(p,r) = \bar{a}(r) + \bar{p}, \tag{5}$$

where $\bar{p}$ is the unconditional mean of $\tilde{p}$. The equilibrium report of insiders is the same as before.

2.2 Outsiders delegate

Now suppose insiders are allowed to choose scale. They will choose

$$s(a,t) = a + \bar{p}(t) + b, \tag{6}$$

where $\bar{p}(t) = E(\tilde{p}|t)$, and the expectation is with respect to insiders' posterior belief about $\tilde{p}$ given outsiders' report, t, and the fact that the decision has been delegated. Since outsiders delegate the scale choice only when $\tilde{p} \geq p^*$, insiders, if given the decision, can infer that $\tilde{p} \geq p^*$. It is shown in Harris and Raviv (2005) that in the Pareto-best Bayes equilibrium outsiders will partition the interval $[p^*,P]$ into $N(b,P - p^*)$ cells and report a value that is uniformly distributed on the cell in which the true realization of $\tilde{p}$ lies. Thus insiders' posterior belief about $\tilde{p}$ is that it is uniformly distributed on the cell that contains the true value. It follows that if the report t is in $[p_i,p_{i+1}]$, $\bar{p}(t) = (p_i + p_{i+1})/2$. The width of the partition cells in this case *decreases* by $4b$ for each unit increase in i. That is, larger ps result in smaller reported intervals, so the reports contain more information.

2.3 Outsiders' delegation decision

Here, we analyze the outsiders' decision of whether to delegate the scale choice to insiders. We show that when outsiders are informed, they will delegate if and only if $\tilde{p} \geq p^*$, and when outsiders are not informed, they will delegate if and only if $b \leq \sigma_a$. Intuitively, when outsiders learn that $\tilde{p}$ is large, they convey more of their information, as discussed above. There is thus less to lose from delegating to insiders. When outsiders are uninformed, they will delegate to informed insiders unless agency costs exceed the full value of insiders' information. We also characterize the cutoff value, p^*.

First, suppose outsiders are informed. To determine when informed outsiders will delegate the scale decision to insiders, the following notation will be useful. Let $L(b,X)$ be the information cost, that is, expected loss in profits, of having only information that is transmitted in equilibrium about a random variable that is uniformly distributed on an interval of width X. That is,

$$L(b,X) = E[\bar{x}(r(\tilde{x})) - \tilde{x}]^2, \tag{7}$$

where $\tilde{x}$ is uniform on an interval of width X, r is the equilibrium report of the party that observes $\tilde{x}$, and $\bar{x}(r)$ is the decision-maker's equilibrium posterior mean of $\tilde{x}$. An explicit formula for L is given in Harris and Raviv (2006). Here we simply note that $L(b,X)$ depends on how much information is transmitted in the report, as measured by $N(b,X)$. In particular, if $N(b,X) = 1$, that is, no information is transmitted to the decision-maker, then $L(b,X)$ is the entire variance, $\sigma^2(X)$, of the unobserved variable. If some information is transmitted [$N(b,X) > 1$], the expected cost is smaller than the variance.

Next, suppose outsiders are in control of the board and x is such that outsiders will delegate the scale choice to insiders whenever outsiders' private information exceeds $P - x$. Furthermore, suppose insiders know that the choice will be delegated to them only when outsiders' private information exceeds $P - x$. Define $f(b,x)$ as the expected information-plus-agency cost when scale choice is delegated, given that the outsiders' private information is exactly x, and delegation involves communication as in the above equilibrium.[15] Some properties of f and L that are used in later proofs are shown in Lemma 1 (Harris and Raviv 2006).

If the scale choice is not delegated to insiders, the actual information cost is given by the square of the deviation of outsiders' choice of s, $\bar{a}(r(\tilde{a})) + \tilde{p}$, from the true realization of $\tilde{a} + \tilde{p}$, that is, $[\bar{a}(r(\tilde{a})) - \tilde{a}]^2$. Thus, the expectation of this cost over $\tilde{a}$, using the above equilibrium value for r, is $L(b,A)$. Essentially, the cutoff, p^*, is determined as the value such that the expected cost of delegating if, in fact, $\tilde{p} = p^*$, $f(b,P - p^*)$, is the same as the cost of not delegating, $L(b,A)$. This is stated formally in the following lemma, which is shown in Harris and Raviv (2005).

Lemma 2. ***(Delegation decision of informed outsiders.)*** *If outsiders are informed that $\tilde{p} = p$, they will delegate the choice of scale to insiders if and only if $p \geq p^*$, where p^* is as follows. If $b \geq \sigma_a$, $p^* = P$, that is, outsiders do not delegate, regardless of their information. If $f(b,p) \leq L(b,A)$, $p^* = 0$, that is, outsiders delegate the decision to insiders,*

[15] One can also interpret f symmetrically for the case in which insiders control the board. In that case, one assumes that insiders will delegate only when their private information is at or below x. Then f is the expected loss to insiders when they delegate the scale choice to outsiders, given that the insiders' private information is exactly x.

regardless of their information (we refer to this case as ***insiders' information is critical****). Otherwise, p* ϵ (0,P) and is defined by*

$$f(b,P-p^*) = L(b,A). \tag{8}$$

In this case, P – p is independent of P.*

The term "insiders' information is critical" is justified by the fact (implied by Lemma 1) that if $f(b,P) \leq L(b,A)$, then $\max\{b,6\sigma_p\} < \sigma_a$, that is, insiders' information is more than six times as important as outsiders' information and more important than agency costs. It is also justified by its implication that outsiders always delegate. Lemma 2 is illustrated in Figure 2, which shows how the delegation decision of informed outsiders depends on agency costs and the importance of the parties' information.

Now suppose outsiders do not become informed. If they delegate the scale decision to insiders, insiders choose $s = \bar{p} + \tilde{a} + b$, where $\bar{p}$ is the unconditional mean of $\tilde{p}$, and the expected information-plus-agency cost is $E\left((\bar{p} - \tilde{p} + b)^2\right) = \sigma_p^2 + b^2$. If outsiders do not delegate, the expected information-plus-agency cost is $E\left((\bar{a}(r(\tilde{a})) - \tilde{a} + \bar{p} - \tilde{p})^2\right) = L(b,A) + \sigma_p^2$.

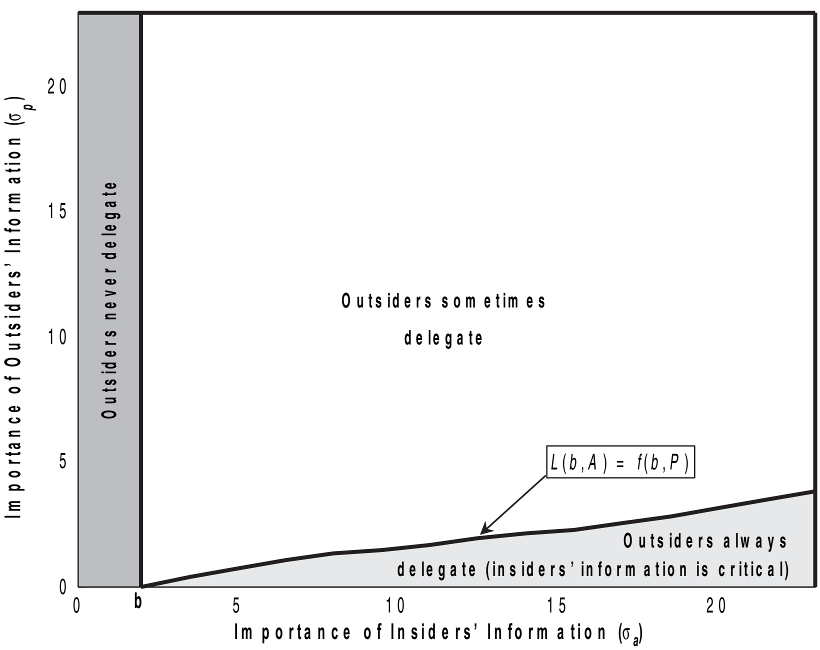

Figure 2
Delegation for an outsider-controlled board (OCB)
This graph shows how the delegation decision of informed outsiders depends on agency costs and the importance of the parties' information for an OCB.

Thus, when outsiders are not informed, they will choose to delegate if and only if $b^2 < L(b,A)$. It follows from Lemma 1 that this condition is equivalent to $b < \sigma_a$, which implies that $N(b,A) = 1$ and hence that $L(b,A) = \sigma_a^2$. Consequently, when uninformed, outsiders delegate to insiders if and only if $b < \sigma_a$. The information-plus-agency cost in this case, denoted l_U (the subscript U is for "uninformed"), is

$$l_U = \sigma_p^2 + \min\{b^2, \sigma_a^2\}. \tag{9}$$

We summarize the above result in the following lemma.

Lemma 3. ***(Delegation decision of uninformed outsiders.)*** *When uninformed, outsiders delegate to insiders if and only if insiders' information is more important than agency costs ($b < \sigma_a$). The information-plus-agency cost in this case, l_U, is given in Equation (9).*

2.4 Outsiders' equilibrium effort

Each outsider will choose his or her effort to maximize his or her share of expected profits net of effort costs. Consider the effort investment decision of an individual outsider, given that all $n - 1$ other outsiders invest e.[16] If the given outsider chooses effort x, the probability that at least one outsider will become informed is given by $1 - (1 - e)^{n-1}(1 - x)$. Denote by l_I the information-plus-agency cost given that outsiders are informed (hence the subscript I). An explicit expression for l_I will be developed presently; for now it suffices to note that l_I does not depend on outsider effort. Recall that l_U is the corresponding cost when outsiders are uninformed, defined in Equation (9). Then expected profits are given by

$$\begin{aligned}\pi_0 - &\left\{\left[1-(1-e)^{n-1}(1-x)\right]l_I + (1-e)^{n-1}(1-x)l_U\right\}\\ &= \pi_0 - l_I - (1-e)^{n-1}(1-x)V_{\mathrm{OCB}},\end{aligned}$$

where $V_{\mathrm{OCB}} = l_U - l_I$ is the marginal value of outsiders' information with an OCB. The given outsider therefore chooses effort x to maximize his or her share α of the above expected profits minus his or her effort cost, that is, to maximize

$$\alpha\left[\pi_0 - l_I - (1-e)^{n-1}(1-x)V_{\mathrm{OCB}}\right] - c(x).$$

The first-order condition for the optimal effort is

[16] We consider only symmetric Nash equilibria of the outsiders' effort choice game.

$$c'(x) = (1 - e)^{n-1} \alpha V_{\mathrm{OCB}} \tag{10}$$

provided there is an interior solution. To interpret Equation (10), note that αV_{OCB} is the individual outsider's share of the marginal value of outsiders' information. By increasing his or her effort, the given outsider increases by that amount the probability of receiving this benefit but only if no other outsiders become informed. The probability that none of the other $n - 1$ outsiders becomes informed, given that each exerts effort e, is $(1 - e)^{n-1}$. Thus, the right-hand side of Equation (10) is the marginal expected benefit of extra effort for any given outsider. Obviously, the left-hand side is the marginal cost of additional effort. Thus, the condition for optimal effort is just the usual marginal-cost-equals-marginal-benefit condition.

All outsiders choosing e is a Nash equilibrium if and only if, given that all other outsiders choose effort e, it is optimal for our given outsider to choose e, that is, if and only if $x = e$ satisfies Equation (10):

$$c'(e)(1 - e) = (1 - e)^{n} \alpha V_{\mathrm{OCB}} \tag{11}$$

again provided there is an interior solution of Equation (11).

To make sure the first-order condition (10) is necessary and sufficient for a maximum and to obtain an interior solution for the equilibrium effort for at least some parameter values, we require the following assumption regarding the cost function c.

Assumption 2. *The cost c is assumed to be strictly increasing and strictly convex in e. Also, assume $c(0) = 0$, and the function $c'(e)(1 - e)$ is convex and has a unique, interior minimum over [0,1] at $e^* \in (0,1)$.*[17]

It is easy to check that under Assumption 2, for $n > 0$, Equation (11) has a unique solution, $e_n(\alpha V_{\mathrm{OCB}}) \in (0,1)$, that is increasing in αV_{OCB} and decreasing in n, provided that the marginal cost of effort for an outsider at zero effort is less than the outsider's share of the marginal value of becoming informed, that is, provided that $\alpha V_{\mathrm{OCB}} > c'(0)$ (Figure 3). If this condition is satisfied, we say that *effort cost is not prohibitive*. If effort is prohibitively costly, the only Nash equilibrium is $e = 0$, that is, outsiders will not invest any effort to become informed (and, therefore, will not become informed for sure). Otherwise, outsiders will invest more effort if the marginal value of becoming informed, V_{OCB}, is larger, outsiders' share of profits, α, is larger, and if the number of outside board members, n, is smaller, other things equal. The last implication is the result of free

[17] An example of a cost function that satisfies Assumption 2 is given in Harris and Raviv (2006).

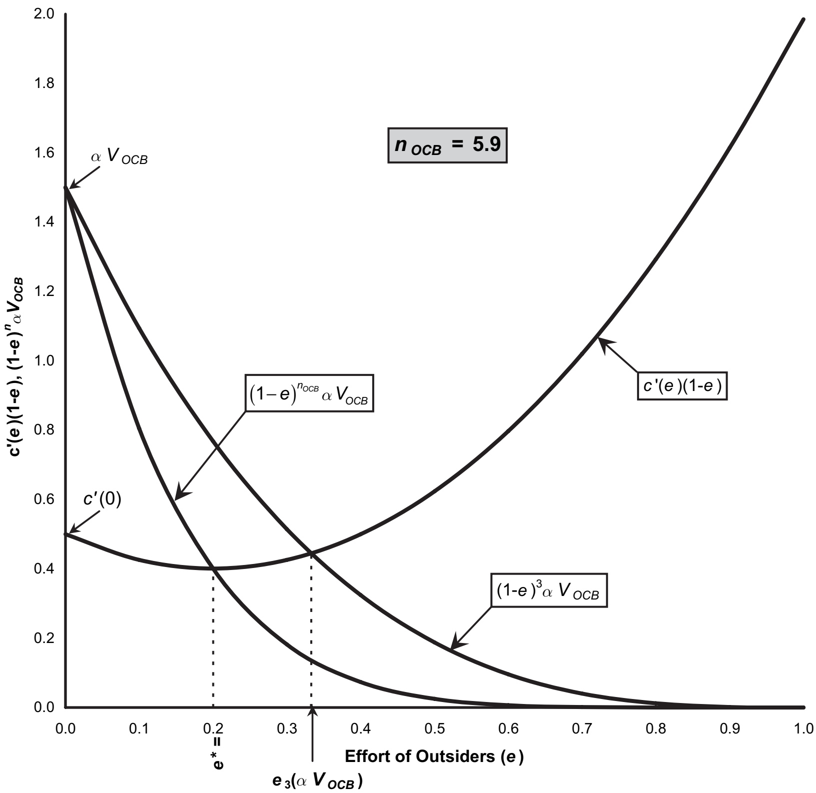

Figure 3
Equilibrium effort and optimal number of outsiders for outsider-controlled board (OCB)
The figure shows the determination of equilibrium effort for an OCB with three outsiders, $e_3(\alpha V_{\mathrm{OCB}})$. It also shows the determination of the optimal number of outsiders, n_{OCB}. For this figure, $c'(e)(1-e) = 0.5 - 2.475e(0.4 - e)$ and $\alpha V_{\mathrm{OCB}} = 1.5$.

riding by outside board members. This free riding induces a tradeoff in choosing the optimal number of outside board members. For given effort, having more outsiders increases the chance that at least one outsider will become informed. Because of free riding, however, having more outsiders on the board reduces the effort of all outsiders. We will exploit this tradeoff in choosing the optimal number of outsiders.

We now develop an explicit expression for the marginal value of outsiders' information, V_{OCB}. If outsiders delegate, the information-plus-agency cost is given by the square of the difference between the insiders' choice of s, $\tilde{a} + \bar{p}(t(\tilde{p})) + b$, and the true realization of $\tilde{a} + \tilde{p}$, that is, $[\bar{p}(t(\tilde{p})) - \tilde{p} + b]^2$. Since outsiders delegate if and only if $\tilde{p} \in [p^*, P]$, the expected cost when outsiders delegate is

$$E\left(\left[\bar{p}(t(\tilde{p})) - \tilde{p} + b\right]^2 \middle| \tilde{p} \in \left[p^*, P\right]\right) = L\left(b, P - p^*\right) + b^2.$$

Given that outsiders become informed, the probability that they do not delegate to insiders is p^*/P. Recall that if outsiders do not delegate when informed, the expected information-plus-agency cost is $L(b,A)$. Therefore, conditional on outsiders becoming informed, but before knowing the value of $\tilde{p}$, the expected cost is

$$l_I = \frac{p^*}{P} L(b,A) + \left(1 - \frac{p^*}{P}\right)\left[L\left(b, P - p^*\right) + b^2\right]. \tag{12}$$

From Equations (9) and (12), it follows that the marginal value of outsiders' information with an OCB is given by

$$\begin{aligned} V_{\mathrm{OCB}} &= l_U - l_I \\ &= \sigma_p^2 + \min\{b^2, \sigma_a^2\} \\ &\quad - \left\{\frac{p^*}{P} L(b,A) + \left(1 - \frac{p^*}{P}\right)\left[L\left(b, P - p^*\right) + b^2\right]\right\}. \end{aligned} \tag{13}$$

We summarize the results of this subsection and the previous subsection in the following proposition.

Proposition 1. ***(Outsiders' equilibrium effort and delegation decision when they are in control.)*** *Assume the board is outsider-controlled.*

1. *If effort cost is not prohibitive ($\alpha V_{OCB} > c'(0)$), then equilibrium effort of outsiders when there are n outsiders, $e_n(\alpha V_{OCB}) \in (0,1)$, is given by the unique solution of Equation (11); otherwise the equilibrium effort of outsiders is zero.*
2. *If agency costs are more important than insiders' information ($b \geq \sigma_a$), then outsiders never delegate, whether they become informed ($p^* = P$) or not, and insiders do not communicate any information about $\tilde{a}$ ($N(b,A) = 1$). The marginal value of outsiders' information is the full value of outsiders' information $\left(V_{OCB} = \sigma_p^2\right)$*
3. *If insiders' information is critical [$f(b,P) \leq L(b,A)$], then outsiders always delegate, whether they become informed ($p^* = 0$) or not. In this case, $V_{OCB} = \sigma_p^2 - L(b,P) \geq 0$.*
4. *If agency costs are less important than insiders' information ($b < \sigma_a$), and insiders' information is not critical [$f(b,P) > L(b,A)$], then outsiders sometimes delegate when they are informed [$p^* \in (0,P)$*

and is given by the solution to (8)] *and always delegate when they are uninformed. In this case,* $P - p^*$ *is independent of* P.

Note that p^* is not the cutoff that minimizes the expected information-plus-agency cost given that outsiders are informed, l_I. In fact p^* is larger, relative to P, than is optimal, that is, outsiders, when in control, fail to delegate sufficiently often relative to the importance of their information. Thus, outsiders could reduce the information-plus-agency cost if they could commit, before becoming informed, to a smaller cutoff for delegating the scale decision. The reason that p^* is not optimal is that the choice of p^* affects insiders' inference about $\tilde{p}$. This can lead to the counter-intuitive result that the marginal value of outsiders' information may be negative. In particular, when $p^* \in (0,P)$, *not* becoming informed may improve expected profits, because it leads outsiders to delegate to insiders for sure, whereas if outsiders become informed, they will delegate a suboptimal fraction of the time. Obviously, for the marginal value of outsiders' information to be negative, it must be true that agency costs are relatively small and insiders' information relatively important. Indeed, we see from Proposition 1 that when agency costs are large, so that outsiders fail to delegate even if they do not become informed, the marginal value of outsiders' information is positive. And, when insiders' information is critical, so that outsiders always delegate, the marginal value is non-negative. Later, we will show that when outsiders have no access to private information, it is always (weakly) optimal for them to control the board, but when outsiders have access to private information, it is sometimes strictly optimal for insiders to control. The fact that outsiders do not delegate optimally when informed also accounts for this counter-intuitive result.

2.5 Optimal number of outsiders for OCBs

We assume that shareholders choose the number of outside board members to maximize the expectation of their share of profits, that is, profits net of payments to outsiders. Recall that the compensation paid to outsiders is assumed to be negligible compared to expected profits and hence is ignored when choosing the number of outsiders. Shareholders will therefore choose the number of outsiders, n_{OCB}, to solve the following problem:

$$\max_{n \in Z} \pi_0 - l_U + \{1 - [1 - e_n(\alpha V_{\mathrm{OCB}})]^n\} V_{\mathrm{OCB}}, \tag{14}$$

where Z is the set of non-negative integers. This problem is equivalent to $\min_{n \in Z} (1 - e_n(\alpha V_{\mathrm{OCB}}))^n$. Thus, the object is to minimize the probability that outsiders fail to become informed, given that this probability is determined by the number of outsiders and their share of the marginal value of becoming informed.

Assuming that effort cost is not prohibitive, we can use Equation (11) to write the objective function as

$$(1-e_n)^n = \frac{c'(e_n)(1-e_n)}{\alpha V_{\mathrm{OCB}}}. \tag{15}$$

Thus, in this case, n_{OCB} can be chosen to minimize $c'(e_n)(1-e_n)$. Since incorporating the integer constraint makes subsequent calculations intractable and ignoring it results in values for n_{OCB} that closely approximate the integer value, hereafter we ignore the integer constraint on the number of outsiders. Using Assumption 2, the optimal n is such that $e_n = e^*$ (Figure 3), that is,

$$n_{\mathrm{OCB}}(\alpha V_{\mathrm{OCB}}) = \frac{\ln \frac{c'(e^*)(1-e^*)}{\alpha V_{\mathrm{OCB}}}}{\ln(1-e^*)}. \tag{16}$$

If effort is prohibitively costly, the equilibrium effort of outsiders is zero, and the optimal number of them is one.[18]

It is easy to check that n_{OCB} is increasing. Intuitively, in our model, regardless of α and V_{OCB}, as long as effort cost is not prohibitive, the equilibrium effort will be e^*. That is, the number of outsiders is determined to make equilibrium effort of outsiders e^*, which depends only on the effort cost function. When outsiders' share of the marginal value of becoming informed, αV_{OCB} , increases, outsiders will increase their effort. To prevent this, the number of outsiders must increase so that the free-rider problem causes them to continue to choose e^*. This result follows from three key assumptions of the model: (i) the function $c'(e)(1-e)$ has a unique minimum on [0,1], (ii) to take advantage of the private information available to outsiders requires only that at least one of them learn it, and (iii) in computing profits, the cost of outside board members is negligible.

It also follows from this observation and Equation (14) that the maximum expected profit with an OCB, obtained by choosing the optimal number of outsiders, is given by

$$\pi^*(\mathrm{OCB}) = \pi_0 - l_U + \begin{cases} [1-(1-e^*)^{n_{\mathrm{OCB}}}]V_{\mathrm{OCB}}, \text{ if } c'(0) < \alpha V_{\mathrm{OCB}}, \\ 0, \text{ if } c'(0) \geq \alpha V_{\mathrm{OCB}}. \end{cases} \tag{17}$$

[18] Since we ignore the cost of outsiders in choosing the optimal number of them, strictly speaking, any positive number of outsiders would be equally good (at least one outsider is needed for outsider control). If we use the (negligible) cost to break ties, however, the optimal number of outsiders would be one.

3. Insider-Controlled Boards

Our goal is to determine board control endogenously by comparing the profitability of OCBs and ICBs. Consequently, having analyzed OCBs in the previous section, we now analyze ICBs.

3.1 Outsiders' equilibrium effort and insiders' delegation decision

If insiders control the board, they may choose scale or delegate the choice of scale to outsiders. The sequence of events in this case is assumed to be the following. First, outsiders choose effort and become informed or not. Next, insiders observe $\tilde{a}$ and whether outsiders are informed and decide whether to delegate the choice of scale to outsiders. They will not delegate if outsiders fail to become informed. Finally, either outsiders or insiders choose scale, depending on the outcome of the insiders' delegation decision.

It can be shown, using the same argument as in Theorem 2 of Harris and Raviv (2005), that insiders will prefer to delegate if and only if $a \leq a^*$, for some cutoff a^*. The analyses of outsiders' choice of scale and insiders' choice of scale proceeds as in the case in which outsiders are in control of the board as discussed above, with obvious modification. It follows that outsiders' equilibrium effort choice with an ICB is determined by

$$c'(e) = (1-e)^{n-1}\alpha V_{\mathrm{ICB}}, \tag{18}$$

where V_{ICB} is the marginal value of outsiders' becoming informed with an ICB, that is, $V_{\mathrm{ICB}} = l'_U - l'_I$, and provided Equation (18) has an interior solution, that is, provided $\alpha V_{\mathrm{ICB}} > c'(0)$. The quantities l'_U and l'_I are the counterparts, for ICBs, of l_U and l_I , that is, the information costs given outsiders do not (do, respectively) become informed. Formally,

$$l'_U = \sigma_p^2 + b^2 \text{ and } l'_I = \frac{a^*}{A}L(b,a^*) + \left(1 - \frac{a^*}{A}\right)\left(L(b,P) + b^2\right). \tag{19}$$

The basic results for ICBs are given in the following proposition (the proof is omitted, since it is quite similar to that of Proposition 1).

Proposition 2. ***(Outsiders' equilibrium effort and insiders' delegation decision when insiders are in control.)*** *Assume the board is insider-controlled.*

1. *If effort cost is not prohibitive* $[\alpha V_{ICB} > c'(0)]$, *then the equilibrium effort of outsiders when there are n outsiders is* $e_n(\alpha V_{ICB}) \in (0,1)$, *which is given by Equation* (18)*'s unique solution; otherwise, the equilibrium effort of outsiders is zero.*

2. *If outsiders are uninformed or outsiders' information is less important than agency costs* $\left(\sigma_p \leq b\right)$, *then insiders never delegate* $(a^* = 0)$. *In either case, outsiders do not communicate any information. In this case, there is nothing to be gained by outsiders' becoming informed* $(V_{ICB} = 0)$.
3. *If* $f(b,A) \leq L(b,P)$, *then insiders always delegate when outsiders are informed* $(a^* = A)$. *In this case,* $max\{b, 6\sigma(a^*)\} \leq \sigma_p$ *and* $V_{ICB} = \sigma_p^2 + b^2 - L(b,A) > 0$. *We refer to this case as one in which outsiders' information is critical.*
4. *If outsiders' information is more important than agency costs* $\left(\sigma_p > b\right)$, *but not critical* $[f(b,A) > L(b,P)]$, *then insiders sometimes delegate if outsiders are informed, that is,* $a^* \in (0,A)$ *and is given by the solution of*

$$f\left(b,a^*\right) = L(b,P). \tag{20}$$

In this case, a^* is independent of A, and $V_{\text{ICB}} > 0$.

Figure 4 shows how the delegation decision of insiders depends on agency costs and the importance of the parties' information.

3.2 Optimal number of outsiders for ICBs

As in the case of OCBs, we assume that the number of outsiders is chosen to maximize expected total profits.[19] Therefore, with an ICB, the optimal number of outsiders, n_{ICB}, solves $\min(1 - e_n(\alpha V_{\text{ICB}}))^n$. Thus, the optimal number of outsiders with an ICB^n is

$$n_{\text{ICB}} = \begin{cases} \dfrac{\ln \frac{c'(e_*)\left(1-e_*\right)}{\alpha V_{\text{ICB}}}}{\ln(1-e^*)}, & \text{if } c'(0) < \alpha V_{\text{ICB}}, \\ 0, \text{ otherwise,} \end{cases} \tag{21}$$

and the equilibrium effort of outsiders is e^* if $c'(0) < \alpha V_{\text{ICB}}$ and zero otherwise.

The maximum profit obtainable with an ICB is

$$\pi^*(\text{ICB}) = \pi_0 - l_U' + \begin{cases} [1 - (1 - e^*)^{n_{\text{ICB}}}] V_{\text{ICB}}, \text{ if } c'(0) < \alpha V_{\text{ICB}}, \\ 0, \quad \text{if } c'(0) \geq \alpha V_{\text{ICB}}. \end{cases} \tag{22}$$

[19] Even if insiders capture the board selection process, they would choose the same number of outsiders as would shareholders, provided that, as we assume, the choice of board control can be separated from the choice of the number of outsiders.

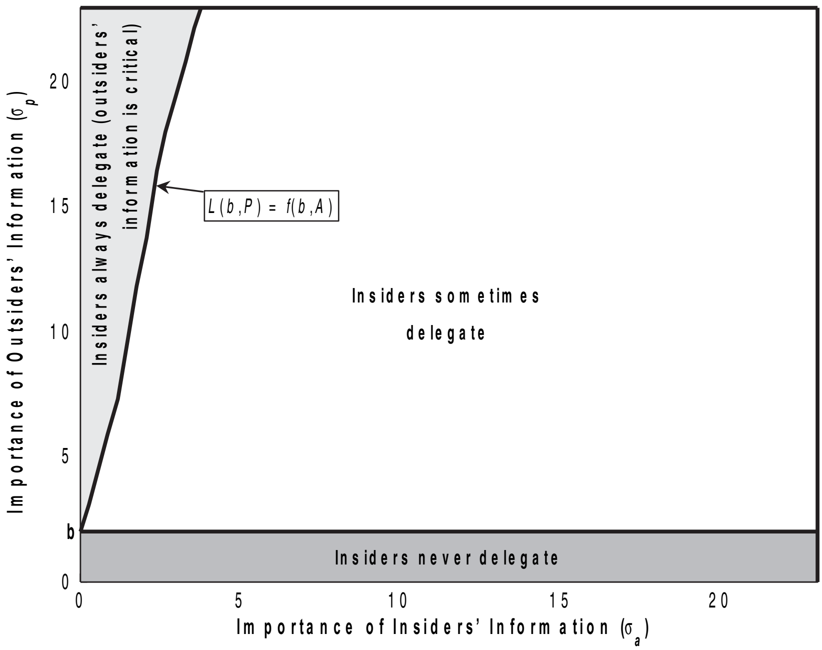

Figure 4
Delegation for an insider-controlled board (ICB)
This graph shows how the delegation decision of insiders depends on agency costs and the importance of the parties' information for an ICB.

4. OCBs versus ICBs

In this section, we derive the optimal board control from the point of view of shareholders.[20] In deriving optimal board control, it is important to remember that the party who controls the board need not make the scale decision. Board control bestows an option either to choose scale or to delegate this choice to the other party. Consequently, our results include not only who controls the board but also under what circumstances the controlling party delegates the scale choice.

4.1 Dependence of board control on importance of information

Our results in this subsection relate the profit-maximizing board control to the importance of the insiders' and outsiders' information, σ_a and σ_p . The formal results are stated below and are shown graphically in Figure 5, which shows optimal control for various combinations of the importance

[20] In interpreting our results on board control empirically, one must assume that the board selection process is not captured by insiders. If it is, one expects the board to be insider-controlled, regardless of the implication for profits. See Shivdasani and Yermack (1999) and the references cited therein for some evidence regarding insider control of the board selection process.

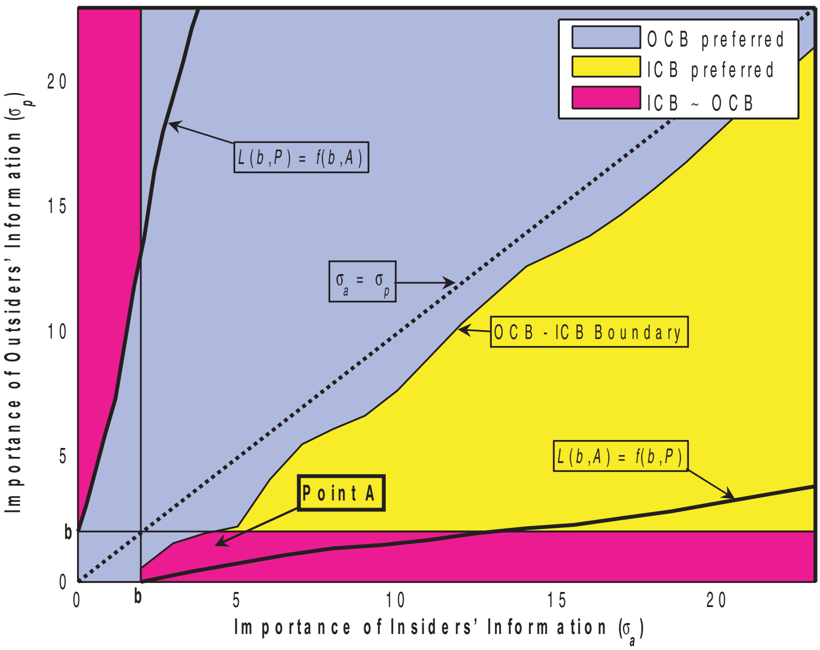

Figure 5
Optimal board control
This figure shows, for various combinations of the two parties' information importance, whether shareholders prefer an OCB, an ICB or are indifferent. For this example, $b = 2$, $\overline{U} = 1$, $\pi_0 = 600$, and $c(e) = -\gamma \ln(1-e) - \varepsilon\{\frac{1}{2}e^2 + (1-2\delta)[e + \ln(1-e)]\}$, with $\delta = e^* = 0.2$, $\varepsilon = 0.0012375$, and $\gamma = c'(0) = 0.0005$.

of the two parties' information for a numerical example. The figure shows that outsider control is preferred when outsiders' information is sufficiently more important than that of insiders and conversely for insider control. In particular, the boundary that divides the region where outside control is optimal from that where inside control is optimal is upward sloping and below the forty-five degree line.[21]

One can understand these results by considering the following basic trade-offs. The controlling party decides, based on their information (if any), who chooses scale. For insiders (outsiders), this decision is determined by who will choose s closest to insiders' (outsiders') ideal point, taking account of the extent of communication. Moreover, control may also affect outsiders' incentives to become informed. Ignoring the issue of outsiders' incentives to become informed and the expected amount of

[21] We show below (see Corollary 1) that this boundary lies below the forty-five degree line. Although we cannot prove that it is monotone increasing analytically (except when agency costs are very small; see Corollary 2), we have verified it for a wide range of numerical examples. The other properties of Figure 5 are shown in general.

communication, the other considerations suggest that it is optimal for insiders to control the board only when their information is sufficiently more important than that of outsiders to offset the fact that insiders are biased toward larger scale. This partial intuition is reflected in Figure 5. That is, as suggested by the basic trade-offs, it is optimal for insiders to control the board only when their information is sufficiently more important than that of outsiders.

This partial intuition does not, however, explain the areas in the figure for which shareholders are indifferent with respect to board control. One reason for this indifference is the effect of board control on the incentives of outsiders to become informed. For example, consider the point labeled A in Figure 5. The essential characteristics of point A are that insiders' information is important relative to outsiders' information and agency costs and that outsiders' information is less important than agency costs. The first characteristic implies that if outsiders control the board, they will be very likely to delegate to insiders (notice that point A is relatively close to the boundary at which insiders' information becomes critical and outsiders always delegate). The second characteristic implies that, when they do delegate to insiders, outsiders will communicate none of their information to insiders. Together, these two facts imply that outsiders, when in control, have little incentive to become informed. In fact, for this example, their incentive to become informed when in control is below their marginal cost of effort at zero effort. Consequently, if they are in control, outsiders never become informed and hence always delegate. If insiders control the board, they never delegate and so always choose scale with no information from outsiders. Thus, in this case, regardless of who controls the board, insiders always choose scale with no information from outsiders.

The previous discussion highlights the complicated interactions among the delegation decision, the extent of communication, and the incentives for outsiders to invest effort in becoming informed that together determine optimal board control. In the rest of this section, we analyze board control more carefully, taking account of these interactions. To compare the two board types analytically, we must simplify the model by assuming that the share of profits going to outsiders, α, is exogenous.[22] We also assume that $c'(0) < \alpha b^2$. This eliminates some uninteresting cases in which effort cost is prohibitive.

It is convenient to divide the population of firms into types based on whether each party's information is critical and whether, if it is not critical, it is more or less important than agency costs.[23] This results in

[22] Numerical simulations with endogenous α indicate that the results on board control are not affected by this assumption.

[23] Recall that if insiders' information is critical, outsiders always delegate to insiders, and if outsiders' information is critical, insiders always delegate to outsiders if the latter are informed.

four types of firms as shown in Figure 6. For both type-I and type-IV firms, neither party's information is critical. For type-I firms, agency costs are more important than at least one party's information. For type-IV firms, agency costs are less important than either party's information. Insiders' information is critical for firms of type II, and outsiders' information is critical for firms of type III. For each type of firm, we derive the optimal board control, taking account of when the controlling party will delegate to the other party (as shown in sections 2 and 3).

Our results are summarized in Table 1 and proved in Harris and Raviv (2006).

Type IV firms are the most complicated, and, consequently, little can be said in general about the relation between board preference of shareholders and the exogenous parameters in this case. Nevertheless, numerous numerical simulations suggest that Figure 5 is representative.

In one special case of type-IV firms of particular interest, however, we can say which board type is preferred. This is the case in which outsiders and insiders have more or less equally important information. As argued at the beginning of this section, one might expect that shareholders would

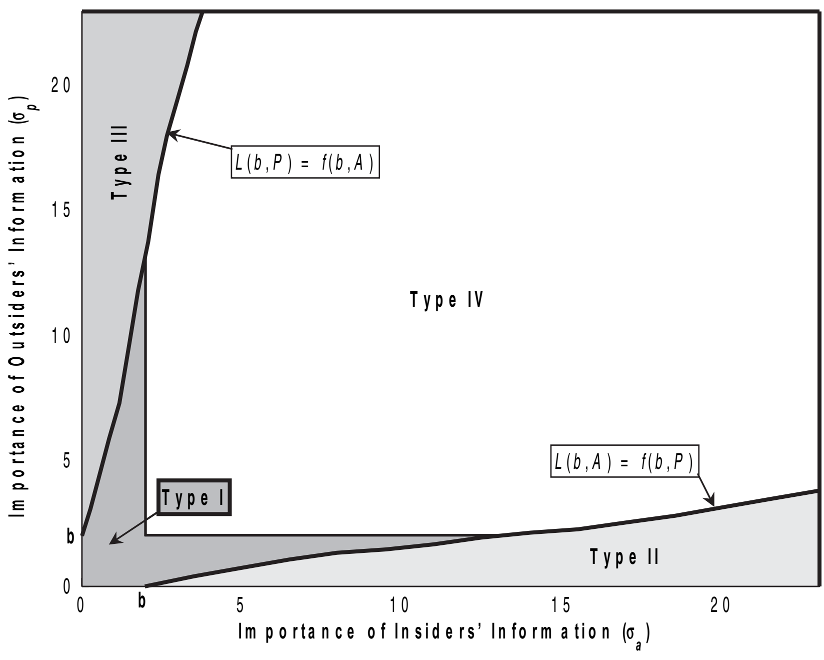

Figure 6
Firm types
This figure shows the four firm types as defined in section 4. For this diagram, b = 2.

Table 1
Optimal board control

Firm type	Board control	Delegation
I	Outsiders[1]	Yes if σ_a > b, and either outsiders are not informed or $\tilde{p} \geq p^*$
II	Insiders[2]	Yes if σ_p > b, outsiders become informed, and $\tilde{a} \leq a^*$
III	Outsiders[3]	Yes if σ_a > b, and either outsiders are not informed or $\tilde{p} \geq p^*$
IV	Outsiders[4] if $V_{\mathrm{OCB}} > V_{\mathrm{ICB}}$	Yes if either outsiders are not informed, or $\tilde{p} \geq p^*$
	Insiders[4] otherwise	Yes if outsiders become informed, and $\tilde{a} \leq a^*$

[1]This preference is strict unless effort cost is prohibitive if outsiders are in control. Even if effort cost is prohibitive for an OCB, the preference is still strict if b > σ_a and $b \geq \sigma_p$.
[2]This preference is strict unless b $\geq \sigma_p$, or effort cost is prohibitive for an ICB.
[3]This preference is strict if σ_a > b, and effort cost is not prohibitive for an OCB.
[4]If effort cost is prohibitive for both board types, shareholders are indifferent.

prefer an OCB. This is indeed the case as is shown in the next result [the proofs of this and all subsequent results are in Harris and Raviv (2006)].

Corollary 1. ***(Board control when neither party's information is critical, but information is more important than agency costs, and the parties have similar information.)*** *If effort cost is not prohibitive for an OCB, and if insiders and outsiders have information of similar importance, that is, σ_p and σ_a are sufficiently close, then shareholders prefer an OCB.*

The intuition presented at the beginning of this section suggests that, for very small agency costs, shareholders prefer the board to be controlled by the party with the more important information. In fact, this is shown theoretically in the next corollary.

Corollary 2. ***(Board control when neither party's information is critical and agency costs are small.)*** *For sufficiently small agency costs, if effort costs are not prohibitive for either board type, shareholders prefer that the board be controlled by the party with the more important information.*

In terms of Figure 5, Corollary 1 shows that the boundary between the region where outsider control is optimal and the region where insider control is optimal is below the forty-five degree line. Corollary 2 shows that, for very small agency costs, this boundary is approximately the forty-five degree line.

4.2 Dependence of board control on agency costs

The above results on how optimal board control varies with the importance of the insiders' and outsiders' information, for given agency costs, are summarized in Figure 5. How board control depends on agency costs is complicated by the way in which these costs enter into the delegation and communication decisions of the two parties. Although we cannot derive theoretically the dependence of control on agency costs, some numerical examples are instructive in highlighting the incompleteness of the partial intuition given earlier in this section. This intuition suggests that increases in agency costs make OCBs more desirable. This is often the case in our simulations.[24] That is, generally, if agency costs are large, insiders' information must be much more important than outsiders' information for insider-control to be preferred. As agency costs decline, the extent to which insiders' information must be more important than that of outsiders decreases. There are cases, however, in which the result is just the opposite. In particular, for some parameter values, increases in b result in a shift from outsider-control to insider-control. In these cases, the increase in b results in an *increase* in delegation when outsiders are in control. This counterintuitive result is due to the fact that the increase in b reduces communication more when outsiders choose scale (insiders communicate) than when insiders choose scale (outsiders communicate). Meanwhile, the increase in b decreases delegation when insiders are in control, as expected. Essentially, increases in delegation imply that the delegating party's information is less useful. Consequently, in these cases, the increase in agency costs renders the outsiders' information relatively less useful and the insiders' information relatively more useful. This leads shareholders to prefer shifting control from outsiders to insiders.

5. Other Comparative Statics and Empirical Implications

In this section, we examine the effects of changes in the various exogenous parameters of the model on the endogenous variables other than board control. That is, we assume, in this section, either that the parameter changes do not change the optimal board type or that the board type is constrained by regulation or some other factor that is outside our model. We also consider only changes in the parameters that do not affect whether effort cost is prohibitive. Consequently, none of the changes in parameters will affect equilibrium effort of outsiders. Following an examination of the model's comparative statics, we take up their empirical implications.

5.1 Comparative statics

We begin our comparative statics analysis by investigating the effect of changes in the importance of outsiders' information on delegation, the number of outsiders, profits, and outsiders' equity share.

Proposition 3 (OCB). ***(The effect of changes in the importance of outsiders' information for OCBs.)*** *An increase in the importance of outsiders'*

[24] Chester Spatt has suggested that this result of the model, along with the perception that agency costs have risen, can explain the recent trend toward outside control of boards.

information, σ_p , results in (i) a decrease in the probability that outsiders delegate the decision to insiders; (ii) an increase in the number of outsiders;[25] *(iii) a decrease in profits; (iv) an increase in the share of outsiders.*

It is not surprising that when outsiders' information becomes more important, it is optimal to have more of them. Since their effort does not change (recall that the number of outsiders is determined to keep effort constant), this increases the probability that they become informed and, by itself, would increase profits. There are two opposing effects, however. If outsiders either do not become informed or become informed but delegate to insiders, the loss because of their failure to become informed or their refusal to communicate the information fully increases. It turns out that the profit-reducing effects dominate. Since profits decrease, outsiders must be given a larger share of profits to assure their participation.

The corresponding result for ICBs is given in the next proposition.

Proposition 3 (ICB). ***(The effect of changes in the importance of outsiders' information for ICBs.)*** *An increase in the importance of outsiders' information, σ_p , increases the probability that insiders delegate the decision to outsiders. If effort cost is prohibitive, profits fall. Since there are no outsiders in this case, their share is irrelevant, and there is no effect on the number of outsiders. If effort cost is not prohibitive, and outsiders' information is critical, the number of outsiders increases, but profits and the share of outsiders do not change.*

If effort cost is prohibitive, outsiders never become informed, and insiders never delegate to outsiders. Since insiders make the decision with no information about $\tilde{p}$, profits are reduced by the full value of outsiders' information. Any increase in the importance of outsiders' information raises this value and lowers profits.

If effort cost is not prohibitive, and outsiders' information is critical, insiders always delegate if outsiders are informed. Consequently, the increase in the importance of outsiders' information has no effect on profits if outsiders become informed. If they do not become informed, however, insiders choose the scale with no information about $\tilde{p}$, so profits decline with an increase in the importance of outsiders' information, but the marginal value of outsiders' information increases. This leads to an increase in the number of outsiders and an increase in the probability that outsiders become informed that is just sufficient to keep profits the same on average. Thus no change in the share of outsiders is required.

[25] If effort cost is prohibitive, the number of outsiders is not affected. Also, if effort cost is not prohibitive, and insiders' information is not critical but is more important than agency costs, we assume that $\sigma_p > b\sqrt{12}$. If this inequality does not hold, V_{OCB} can be decreasing in σ_p . In this case, it is unclear whether αV_{OCB} increases or decreases, and hence whether the number of outsiders increases or decreases.

Note that the proposition says nothing about the case in which effort cost is not prohibitive and outsiders' information is not critical. It turns out that, in this case, the number of outsiders, profits, and the share of outsiders are not monotone in the importance of outsiders' information.

Proposition 4 (OCB). **(*The effect of changes in the importance of insiders' information for OCBs.*)** *An increase in the importance of insiders' information, σ_a , increases the probability that outsiders delegate the decision to insiders. If insiders' information is less important than agency costs, the number of outsiders increases, profits decrease, and the equity share of outsiders increases.*[26] *If insiders' information is critical or if it is more important than agency costs and effort cost is prohibitive, there is no effect on the number of insiders, profits, or the equity share of outsiders. If insiders' information is more important than agency costs but not critical (and effort cost is not prohibitive), the number of outsiders and profits move in the same direction as each other while the equity share of outsiders moves in the opposite direction.*

The intuition for Proposition 4 (OCB) is as follows. If insiders' information is less important than agency costs, then outsiders never delegate, even if they are uninformed. Consequently, the marginal value of becoming informed is the full value of outsiders' information, which is not affected by the importance of insiders' information. Profits, however, decrease, since outsiders will have less information about $\tilde{a}$ when they choose scale. This requires an increase in outsiders' equity stake to keep their compensation the same. The increased equity stake increases outsiders' share of the marginal value of becoming informed, so to keep outsiders' effort constant at e^*, one must increase the number of outsiders. If either insiders' information is critical or it is more important than agency costs and effort cost is prohibitive, outsiders always delegate, so insiders' information is always fully utilized. There is, therefore, no effect on profits, hence no effect on the equity share of outsiders, no effect on the marginal value of outsiders' becoming informed, and no effect on the optimal number of outsiders.

Unfortunately, one cannot pin down the sign of the effect of a change in the importance of insiders' information when insiders' information is more important than agency costs but not critical, since there are conflicting effects on profits (numerical examples show profits can go either up or down). If, say, profits increase when the importance of insiders' information changes, then so too will the marginal value of outsiders' information. Indeed, the latter will increase by a greater relative amount than the former. Meanwhile, outsiders' share of profits must decrease by

[26] If effort cost is prohibitive, there is no effect on the number of outsiders.

the same percentage that profits increase. Consequently, outsiders' share of the marginal benefit of becoming informed increases. This results in an increase in the optimal number of outsiders. Thus, the number of outsiders and profits move in the same direction.

The corresponding result for ICBs is given in the next proposition.

Proposition 4 (ICB). ***(The effect of changes in the importance of insiders' information for ICBs.)*** *An increase in the importance of insiders' information, σ_a, decreases the probability that insiders delegate the decision to outsiders. If effort cost is prohibitive, there is no effect on profits, the share of outsiders, or the number of outsiders. If effort cost is not prohibitive, an increase in the importance of insiders' information results in (i) a decrease in the number of outsiders; (ii) a decrease in profits; (iii) an increase in the share of outsiders.*

As in the previous result, if effort cost is prohibitive, outsiders never become informed, and insiders never delegate to outsiders. Since insiders make the decision with full information about $\tilde{a}$, profits are unaffected by the change in the importance of insiders' information. As before, the share of outsiders is irrelevant, and the number of outsiders is zero, independent of the importance of insiders' information.

Next we consider the effects of changes in effort cost, potential profits, and the opportunity cost of outsiders. To consider comparative statics on effort cost, we introduce a scale factor $g > 0$ for the cost function, that is, we write $c(e) = gk(e)$, where the function k satisfies Assumption 2.[27] We also consider the effects of changes in potential profit and the opportunity cost of outside directors. These results are valid for both OCBs and ICBs.

Proposition 5. ***(The effect of a change in effort cost.)*** *If effort cost is prohibitive, changes in effort cost, g, have no effect. Otherwise, an increase in effort cost results in a decrease in the number of outsiders, a decrease in profits, and a less-than-proportionate increase in the equity share of outsiders.*

(The Effect of a Change in Potential Profit.) *An increase in potential profits, π_0, results in a decrease in the number of outsiders (or no change if effort cost is prohibitive), an increase in profits, and a decrease in the equity share of outsiders.*

(The Effect of a Change in the Opportunity Cost of Outsiders.) *An increase in the opportunity cost of outsiders, $\overline{U}$, results in an increase in the number of outsiders (or no change if effort cost is prohibitive), an increase in profits, and an increase in the equity share of outsiders.*

[27] Changes in effort cost of the type we consider do not change equilibrium effort when effort cost is not prohibitive, e^*.

The intuition for the results in Proposition 5 is straightforward. An increase in effort costs forces an increase in outsiders' equity share (unless effort cost is prohibitive). The increase in effort costs also dictates a reduction in the number of outsiders to keep them from reducing their effort. The increase in outsiders' equity share partially reverses this effect, but not fully, since the increase in share is less than proportionate to the increase in cost. Since the number of outsiders falls, but their effort stays constant, they are less likely to become informed, and profits fall. An increase in the opportunity cost of outsiders also requires an increase in outsiders' equity share, leading to an increase in the number of outsiders (recall that we ignore the cost of outsiders in computing the optimal number of them). This increases the probability of outsiders becoming informed (more outsiders, same effort) and hence increases profits. An increase in potential profits dictates a reduction in outsiders' equity share which, in turn, requires a decrease in the number of outsiders so as to keep effort constant. There are opposing effects on profits. The increase in potential profits, *cet. par.*, increases expected profits, and the decrease in the number of outsiders, *cet. par.*, decreases expected profits. The net effect is, however, positive, as shown in the proof in Harris and Raviv (2006).

Comparative statics with respect to agency costs, b, are impossible to derive analytically due to the complicated way in which these costs enter the controlling party's delegation decision and the amount of information conveyed. Consequently, we present only numerical comparative statics for b. For ICBs, increases in agency costs reduce delegation, the number of outsiders, and profits but increase outsiders' share of profits. These results are intuitive. For OCBs, an increase in agency costs reduces profits and increases outsiders' share of profits. Such an increase decreases delegation when insiders' information is less important but increases it when insiders' information is more important. The effect on the number of outsiders depends on the importance of the two parties' information in a more complicated way.

We summarize our comparative statics results in Table 2.

5.2 Empirical implications

As can be seen from Table 2, the relationships between the exogenous parameters and the endogenous variables of the model are often quite complicated and, therefore, difficult to test directly. There are some fairly straightforward predictions, however. For example, the model predicts that increases in the importance of the controlling party's information reduce the likelihood that the controlling party delegates the decision to the other party. Just the opposite is true for increases in the importance of the noncontrolling party's information. For OCBs, increases in the importance of outsiders' information increase the number of outsiders,

Table 2
Comparative statics results

Parameter	Effect of parameter increase on: Delegation probability	Number of outsiders	Profits	Outsiders' share
Board type, outsider-controlled board				
σ_p	–	+	–	+
		+[1]	–[1]	+[1]
σ_a	+	0[2]	0[2]	0[2]
		Same as profits[3]	Same as number of outsiders[3]	Opposite[3]
b_4	– for σ_a below cutoff, then +	Depends on σ_a and σ_p	–	+
Board type, insider-controlled board				
σ_p	+	+[5,6] 0[7]	0[5,6] –[7]	0[5,6] 0[7]
σ_a	–	–[5]		
0[7]	–[5]			
0[7]	+[5]			
0[7]				
b^4	–	–	–	+
Board type, both OCB and ICB[5]				
g	0	–	–	+
π_0	0	–	+	–
$\overline{U}$	0	+	+	+

The interpretation of the parameters is as follows: σ_a and σ_p are, respectively, the importance of insiders' and outsiders' information; b is the agency cost; g is the scale parameter for outsiders' effort cost function; π_0 is potential profit and $\overline{U}$ is the opportunity cost of outsiders for serving on the board. None of the parameters affects equilibrium effort unless the change in the parameter causes effort cost to switch from being prohibitive to not being prohibitive or the reverse. We do not consider such cases in this table.
[1]Assumes insiders' information is less important than agency costs.
[2]Assumes insiders' information is critical or is more important than agency costs and effort cost is prohibitive.
[3]Assumes insiders' information is more important than agency costs but not critical and effort cost is not prohibitive.
[4]Results are numerical.
[5]Assumes effort cost is not prohibitive.
[6]Assumes outsiders' information is critical.
[7]Assumes effort cost is prohibitive.

reduce profits, and increase outsiders' share of profits. For ICBs, increases in agency costs reduce delegation, the number of outsiders, and profits but increase outsiders' share of profits. Increases in potential profits reduce the number of outsiders and increase profits for both board types.

The results of the previous subsection also predict relationships between profitability and the number of outside directors caused by variation in one or more of the underlying parameters of the model. For example, the number of outsiders and profits will be negatively correlated if the driving exogenous variable is the importance of outsiders' information or potential profits. None of these results, of course, implies that more or fewer outside directors improves profitability *per se*. Consequently, our approach casts doubt on the interpretations of empirical findings that are prevalent in the empirical literature. For example, our approach calls into question the interpretation of Yermack (1996) and Eisenberg, Sundgren, and Wells (1998) that the negative relation they document between performance and board size implies that large boards are ineffective.

Many researchers have looked for, but failed to find, a relationship between performance, variously measured, and the fraction of outside board members.[28] This seems puzzling given the predominant view that outsider control of boards is beneficial. In our model, the relationship between profits and board size as well as the relationship between profits and the number of outsiders is driven by many factors, some of which cause positive co-variation and others negative co-variation. If more than one exogenous variable changes in the cross section, the effects could cancel out. This could account for the lack of a relationship between performance and the fraction of outside board members.

Rosenstein and Wyatt (1990) interpret their finding that appointment of an outsider to a company's board results in a positive stock price effect as evidence in favor of the view that having more outsiders improves performance.[29] In our model, a firm will add an outside director only after a shock that increases the optimal number of outsiders. Such a shock, for example, a decrease in effort costs of outsiders, could also increase firm value. Thus, our model can account for the finding of Rosenstein and Wyatt (1990) if the firms in their sample are affected largely by shocks that increase both the optimal number of outsiders and profitability. In our model, however, the appointment of an outsider does not cause such an improvement in performance.

These examples highlight the problem with interpreting empirical correlations as if the number of outside board members were exogenous. In particular, our model can account for the empirical regularities without any implication that more outsiders are better or that larger boards are worse.

Another implication of our approach is that, in firms for which insiders' information is very important, boards should have few outsiders and be insider-controlled. One might expect startups, especially those in the

[28] See MacAvoy et al. (1983), Hermalin and Weisbach (1991), Mehran (1995), Klein (1998), and Bhagat and Black (2000).

[29] Rosenstein and Wyatt (1990) states that "These results imply that the expected benefits of outside guidance gained from these appointments outweigh the expected costs of potential managerial entrenchment and inefficient decision making [when insiders choose outside directors]" (p. 176). The authors suggest an alternative interpretation along the lines of this article, however, namely that "the addition of an outside director signals a change in firm strategy rather than the benefits of outside guidance." (p. 176).

high-tech industries, to be in that category and thus to have ICBs with few outsiders.

One can use Proposition 5 to interpret the results of Fich and Shivdasani (2004). They show that firm performance is lower when a majority of outside directors are "busy," that is, sit on three or more boards (relative to performance when the majority of outsiders are not busy). They also show that market value increases when busy outside directors depart, "especially when the departure results in a majority of the remaining outside directors being not busy. When directors become busy as a result of acquiring an additional board seat, firms where they serve as directors experience negative abnormal returns" (Fich and Shivdasani 2004, abstract). If one assumes that the greater the number of boards on which a director sits the greater his or her effort costs for any given board, our model predicts exactly the results of Fich and Shivdasani. Our model also predicts that firms with outside directors who sit on many boards will have fewer such directors than similar firms with outside directors who sit on few boards.

6. Application to Sarbanes-Oxley

Recall that the Sarbanes-Oxley Act mandates, among other requirements, that audit committees of boards of corporations listed on major exchanges have a majority of independent directors. Presumably, the thinking behind this requirement is that outside directors will improve the accuracy of audited financial statements.

A slight modification of our model, applied to audit committees instead of boards, can be used to evaluate the usefulness of the Sarbanes-Oxley rule. Take s to be the earnings report and assume that insiders privately observe true earnings, but outsiders have no information about earnings that insiders do not also possess. Shareholders and outside directors prefer s to be as accurate as possible, but insiders want to inflate earnings to some extent.

With these assumptions, the model works as before, except that outsiders, if in control, will always delegate to insiders, provided insiders' information is more important than agency costs. Also, insiders will never delegate to outsiders (since outsiders have no private information). Assuming that insiders' information is more important than agency costs, our result is that control of the audit committee does not affect the accuracy of the earnings report. If outsiders are in control, they will always delegate to insiders. If insiders are in control, they will never delegate to outsiders. Consequently, regardless of who controls the audit committee, insiders will always choose the earnings report (and, of course, learn nothing from outsiders). That is, the earnings report will be independent of control of the audit committee.

This result implies that the rule that a majority of the members of audit committees be independent is unlikely to increase the accuracy of earnings reports. Indeed, Romano (2005) reaches the same conclusion based on a number of studies that demonstrate the lack of an association between percent (or majority) independence of the audit committee and accounting misstatements. Our theoretical result explains the empirical evidence if one assumes that control of the audit committee is assigned in a manner that is independent of the model's parameters, a reasonable assumption given our conclusion that shareholders are indifferent to this assignment.

7. Conclusions

We have presented a model to determine the optimal control of corporate boards of directors, the number of outside directors, and resulting profits as functions of the importance of insiders' and outsiders' information, the extent of agency problems, and some other factors. In particular, we find that, in many cases, shareholders prefer an insider-controlled board. This result is contrary to conventional wisdom which has it that outside control of boards, or at least of key committees such as the audit committee, is always preferred. This thinking underlies recent legislation, in particular the Sarbanes-Oxley Act, and changes in New York Stock Exchange and NASD listing rules. Our results show, however, that outside board control may, in fact, be value-reducing. In particular, if insiders have important information relative to that of outsiders, giving control to outsiders may result in a loss of information that is more costly than the agency cost associated with inside control. On the other hand, if agency costs are large, our model generally predicts that outsider-control is optimal. In that case, regulations mandating such control are consistent with optimality.

Our model also leads to an endogenous relationship between profits and the number of outside directors that furthers our understanding of some documented empirical regularities. In particular, our model can account for the observed absence of a relationship between the fraction of outsiders on the board and both profits and accounting misstatements, as well as the observed negative relationship between board size and profits.[30] Since these relationships are driven by changes in exogenous parameters in our model, there is no causal relationship. The model thus demonstrates, for example, the pitfall of inferring from the negative relationship between board size and profits that large boards are less effective and suggests that empirical work on corporate board size and composition take the endogeneity issue seriously.

[30] Another possible application of the model is to the relationship between control of the compensation committee of the board and CEO compensation.

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