THE INTERACTION OF INSIDERS AND OUTSIDERS IN MONITORING: A THEORY OF CORPORATE BOARDS

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ABSTRACT

This paper presents a theoretical model of the interaction of inside and outside members of a corporate board. I examine the functioning of corporate boards by focusing on the board’s involvement in the monitoring of firm projects and CEO succession. I show how the board structure affects the flow of information and the effectiveness of the corporate board and I endogenously derive the size and the composition of the corporate board that maximize firm value. I also study how firm characteristics affect the optimal board structure and board effectiveness. For example, I find that firms where verification of projects by outsiders is difficult optimally require a majority proportion of insiders on the corporate board. On average, optimal board size decreases with increases in verification costs (is smaller for firms with higher verification costs). Finally, I also find that there is some residual agency cost even with the optimal board, and this residual agency cost can be used to evaluate the corporate board as a monitoring mechanism.
The Interaction of Insiders and Outsiders in Monitoring: A Theory of Corporate Boards

This paper analyzes the process by which corporate boards monitor managers and make decisions regarding CEO succession. I explicitly model the different groups inside the board (insiders and outsiders) and the effects of their interaction on the monitoring ability of boards. I show how aspects of board structure affect the flow of information to the board and thus its efficiency. In addition to highlighting the role of both inside and outside corporate board members, I endogenously determine the size and the composition of a board that maximize firm value. I also study how the structure of the optimal board and its effectiveness vary with firm characteristics. My model yields several testable implications. For example, I answer the questions: How effective is the corporate board as a monitoring mechanism for a particular industry or firm? For which firms does having a higher proportion of insiders on the board mean higher firm value? When is a large size board more effective in monitoring than a relatively small board?

Corporate boards have been the subject of great interest and debate in recent years both among researchers and practitioners. Among practitioners, large institutional investors such as the California Public Employees Retirement System (CALPERS) have advocated smaller boards with a larger proportion of outsider, assuming that outsiders make boards more independent of management and the smaller board size makes the board more efficient. In the finance literature, Jensen (1993), in his presidential address to the American Finance Association, advocates small size boards with the CEO as the only inside member.

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1 Other large institutional investors demanding boards with mostly outsiders include the Teachers Insurance Annuity Association-College Retirement Equities Fund (TIAA-CREF). For example, in 1997 TIAA-CREF targeted Disney’s board for not being independent enough. In addition, associations involved with corporate governance, such as the National Association of Corporate Directors and the Business Roundtable, have also submitted statements arguing that boards should have a majority of outsiders. See Gillan and Starks (1998) and Karpoff (1998) for further discussion on the influence of institutional investors in corporate governance.
There are a number of empirical papers in finance that study board structure but there are very few theory papers on the subject of corporate boards. Most of the empirical results regarding board size and composition and firm performance have been weak and inconclusive. In terms of board composition, Bhagat and Black (1999) find that adding a small number of insiders on the board may improve firm performance, while Hermalin and Weisbach (1991) and Baysinger and Butler (1985) find some evidence that a higher proportion of outsiders on the board may improve firm performance (see also Mehran (1995) and Klein (1998)). In board size, Yermack (1996) finds evidence of an inverse association between board size and firm market value, while Agrawal and Knoeber (1999) find that larger board size is more common in firms for which politics is more important. Several papers in the literature have also studied the influence of board structure on specific firm decisions that may increase the value of the firm (Borokhovich, Parrino and Trapani (1996); Brickley, Coles and Terry (1994); for example). Others have looked at the market reaction to changes in board structure (Rosenstein and Wyatt (1997), for example), and what firm changes affect board structure (Baker and Gompers (2000); Dennis and Sarin (1999); Kole and Lehn (1999); for example). See John and Senbet (1998) and Hermalin and Weisbach (2000) for reviews of the literature on boards.

The theory literature on boards is still in its early stages and the issue of optimal board size and composition has not been resolved. The literature is interested in understanding the process by which boards monitor management and how board membership and managerial characteristics affect the information and decision making ability of the board. Some of the aspects of the CEO’s influence over the corporate board have been considered. Hermalin and Weisbach (1998) study the process by which the board evolves over time and the CEO’s influence over the board changes over time. The paper shows that the CEO’s tenure with the firm determines the independence of the board and the sensitivity of CEO’s tenure to firm performance. Warther (1998) considers how the CEO’s ability to fire dissenting board members influences the decision making ability of board members. Gutierrez (1999) and Adams (1999) study the CEO’s influence over the information that the board is able to obtain and what board characteristics maximize the incentive of the CEO to reveal his information to the board.

This paper also considers the CEO’s influence over the board members and the information that the board receives. However, my contribution is to study how insiders are an additional source of information to the outside board members and how the different board
members interact with each other. I show that outside board members can use their influence in the board in motivating inside board members to reveal their information. The characteristics of the projects in the firm and the structure of the corporate board determine how effective the board is in generating information and monitoring management. I derive the board size and the board composition that maximize the value of the firm. To the best of my knowledge, this is the first paper in the literature to derive optimal board size and board composition endogenously.

Inside board members are senior managers who work for the firm and sit on the board. They are generally well informed regarding the value of investment projects. However, the incentives of insiders are distorted by private benefits and their lack of independence from the firm’s CEO. Outside board members have no affiliation with the firm other than their board seat. They are better aligned with shareholders because their reputation depends on the value of the firm and their incentives are less distorted by private benefits from firm projects. However, outsiders are less informed regarding projects in the firm, and verifying the value of projects is costly to them.

I model the boards’ monitoring of the projects undertaken by the CEO, and the board’s involvement in the CEO succession decision. Voting on CEO succession in my paper creates a competition among the insiders and it motivates them to reveal their superior information to outside board members, even though their incentives are distorted by private benefits. In solving for the decision of the inside board members on whether to inform the board, I use Coalition-Proof Nash Equilibrium, which allows insiders to make decisions individually as well as in credible coalitions.

Insiders do not always prefer to inform the board and outsiders are not always willing to verify the quality of the projects undertaken by the CEO. The optimal board maximizes the likelihood that the board will monitor and reject bad projects. In general, I find that even an optimal board does not solve the agency problem completely and this provides an estimate of the effectiveness of the corporate board as a monitoring mechanism.

The characteristics of the firm affect the optimal board size and composition and the residual agency from the board.
The characteristics of the firm studied are the difficulty that outsiders have in verifying information provided by insiders (verification costs) and the amount of private benefits that insiders can obtain from sub-optimal projects.

Holding board composition (the ratio of insiders to outsiders) constant, issues related to board size are as follows. Smaller boards have the advantage of less coordination costs among the outside board members, but this comes at the cost of lower incentives for insiders to inform the board. Board size is smaller in firms whose characteristics provide high incentives for insiders to inform the board (low private benefits) or in firms where the incentives of outsiders to monitor are low (verification costs are high).

If board size is held constant but the ratio of insiders versus outsiders is changed, other issues become relevant. Boards with a higher proportion of insiders depend more on the competition among insiders to obtain the support of insiders needed for a majority voting on the project choice, where boards with a majority of outsiders maximize the ability of outside board members to implement their project choice. The proportion of insiders on the board is higher in firms where the incentives of inside board members are better aligned with shareholders (private benefits are low) or in firms where the incentives for outsiders to monitor are low (verification costs are high).

In comparison to other monitoring mechanisms, boards have the advantage that they are able to monitor the firm before projects are implemented, based on information that is not contractible and is not available to the market. I focus on the board’s process of information collecting and monitoring based on that information, while assuming that other mechanisms work efficiently but are unable to solve the agency problem completely. Papers in the board literature have compared boards against other monitoring mechanisms (Maug (1997)), and how boards interact with the external takeover market (Hirshleifer and Thakor (1994)). Noe and Rebello (1997) consider the issue of board composition and finds that a majority of outside board members is sufficient to induce efficient resource allocations.

The paper is organized as follows. Section I describes the project level agency problem, shows how it can lead to implementation of inferior projects, and describes a board setup to monitor the firm. Section II analyzes the board and derives the optimal board composition. Section III analyses the comparative statics results that relate firm characteristics to the optimal board. Section IV concludes.
I. The Model

In this section, I specify the agency technology of the firm and characterize an agency problem. I present a model of the corporate board and describe the general problem of designing the optimal corporate board to solve the agency problem. I assume that all players in this game are risk-neutral utility maximizers.

The entrepreneur has a technology at date \( t=0 \) that consists of a project with two possible implementations. Both implementations require an initial investment of \( I>0 \) at date \( t=2 \) and generate a state-contingent cash flow at date \( t=3 \). Both implementations generate cash flows of \( X>I \) when the project is successful (the good state) and a cash flow of zero when unsuccessful (the bad state).

The implementations differ in their probability of obtaining the bad state. The probability of obtaining the bad state is normalized to zero for implementation 1. It equals \( \Phi \) for implementation 2, where \( \Phi \) is random uniform \((0,1)\). I refer to implementation 1 as the good project and implementation 2 as the bad project, since implementation 2 has a higher probability of reaching the bad state.

The entrepreneur incorporates the firm at \( t=0 \) and hires a CEO and several managers to implement the technology. The firm has enough capital in its cash reserves to invest \( I \) in a project, and the CEO must choose between the good and bad projects. The actual value of \( \Phi \) becomes known to all the inside managers of the firm before the project is implemented at date \( t=1 \), but it is not observed by agents that do not work for the firm.

I assume that external monitoring market (for example takeovers and bankruptcy) is active, in that it takes over the firm and fires the CEO and other senior inside managers if the final cash flows of the firm equal zero. Figure 1 shows the timing of the events for the project.

**FIGURE 1: Project Cycle**

<table>
<thead>
<tr>
<th>Date 0</th>
<th>Date 1</th>
<th>Date 2</th>
<th>Date 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO and managers hired</td>
<td>( \Phi ) becomes known to insiders</td>
<td>Invest ( I ) in one of the projects</td>
<td>Final cash flows generated</td>
</tr>
</tbody>
</table>
A. The Agency Problem

Agency costs arise from private benefits to managers from being in control of the firm. These benefits are assumed to occur in addition to the cash flows from projects and are available only to the inside managers of the firm. The market value of the firm is assumed to reflect only the cash flows from the projects and does not include any part of the benefits of control. Private benefits of control, managerial perks, human capital concerns, and effort aversion are examples of sources of private benefits. See for example, Jensen and Meckling (1976), Grossman and Hart (1988), and Harris and Raviv (1988) for different versions of managerial private benefits of control as a source of agency problems.

The CEO derives private benefits from the bad project at time 3 equal to $\beta$ ($\beta > 0$) if the final cash flows equal $X$ (the good state), but he receives no private benefits from the bad project if the final cash flows equal to zero. If the final cash flows equal zero, external monitoring mechanisms take a disciplinary action and replace the CEO. The CEO derives no private benefits from the good project.

The project choice of the CEO depends on the level of private benefits from the bad project and on his utility from not letting the firm fail. Undertaking the bad project gives the CEO potential private benefits, but he takes a chance of losing his job with probability $\Phi$. Let $U_{CEO}$ be the utility of the CEO from keeping his current job and let his utility from being fired equal to zero. Therefore, the expected utility of the CEO from taking the good project is equal to $U_{CEO}$, and his expected utility from a bad project with probability of failure $\Phi$ equals $(1-\Phi)(\beta + U_{CEO})$. The CEO will prefer to invest in the good project if:

$$U_{CEO} \geq (1-\Phi)(U_{CEO} + \beta)$$

That is, the CEO prefers the good project only if his expected utility from the good project is higher than his expected utility from the bad project. Let $\Phi_{CEO}$ be the lowest (cutoff) value of $\Phi$ that satisfies equation (1) so that the CEO prefers the good project over the bad project. That is,  

\[2\] I follow the convention that private benefits are lost in the state where the project fails. This assumption is not necessary in order to achieve the results of this paper. For example, Harris and Raviv (1988) also used this convention.
\[ \Phi_{\text{CEO}} = 1 - \frac{U_{\text{CEO}}}{U_{\text{CEO}} + \beta} \]  

(2)

The minimum cutoff \( \Phi_{\text{CEO}} \) increases as the CEO’s private benefits from the bad project increase and as his utility from keeping his job (\( U_{\text{CEO}} \)) decreases. The agency cost in the firm is the loss to shareholder value when the manager prefers to undertake the bad project.

The following definition facilitates the comparison of various investment policies:

**Definition 1**: An investment policy of investing in the good project when the probability of failure of the bad project, \( \Phi \), is greater than \( \Phi' \) and investing on the bad project otherwise, will be denoted as investment policy \([\Phi']\).

Given the assumption that the ex-ante probability of failure of the bad project is normally distributed, it is possible to derive the net present value of an investment policy \([\Phi']\), denoted \( V(\Phi') \). With probability \( \Phi' \), the probability of failure of the bad project will be less then \( \Phi' \) and the expected value of the firm will be \([1 - (\Phi'/2)]X \). With probability \((1-\Phi')\) the probability of failure of the bad project will be higher than \( \Phi' \) and the firm will implement the good project with value equal to \( X \). Equation (3) defines \( V(\Phi') \):

\[
V(\Phi') = \left[1 - \frac{(\Phi')^2}{2}\right]X
\]

(3)

Under the optimal investment policy \( \Phi' \) equals 0 and \( V(\Phi') \) equals \( X \) since the firm always invests in the good project. The goal of the shareholders is to provide enough incentives to minimize the maximum probability of failure of the bad project that would cause the manager to prefer the bad project over the good project. In other words, the shareholders prefer to set up an incentive structure that minimizes \( \Phi' \) in investment policy \([\Phi']\).

**B. The Corporate Board**

Monitoring and intervention by a corporate board before a project is implemented could reduce the CEO’s discretion and the probability of his taking the bad project. In this section, I consider monitoring by a board that votes on project implementation and on the CEO-successor choice. All the decisions are based on simple majority vote.
There are three types of players on the board: The CEO, the inside directors who work for the firm and want to become the CEO’s successor, and the outside directors who do not work for the firm but receive reputation benefits from the final value of the firm. All the players in the game know that there is a good project and a bad project and that the CEO can obtain private benefits equal to \( \beta \) from implementing the bad project.

The CEO and corporate insiders observe the probability of failure of the bad project (\( \Phi \)) at time 1, and the CEO proposes either the good project or the bad project to the board based on the observed \( \Phi \). The board must decide at time 2 whether to approve the proposed project. Outside board members do not observe \( \Phi \) and don’t know whether the CEO proposed the good project or the bad project unless they decide to incur costly verification. Let \( \Phi_p \) be the probability of failure of the proposed project. Note that \( \Phi_p \) is equal to zero if the CEO proposes the good project, and \( \Phi_p \) is equal to the observed \( \Phi \) if the CEO proposes the bad project.

I assume that the CEO suggests the alternative project and the board approves and implements the alternative project if the board rejects the project initially proposed by the CEO. The board decides on the CEO successor at time 3 when the final cash flows from the project implemented are observed. The objectives of the inside and the outside board members are described below. The CEO proposes a project based on his incentives as discussed in part A of this section:

1. **Outsiders:** There are “m” identical outsiders on the board who prefer the good project implementation, because each outsider will earn benefits of reputation at time 3 that increase with the final value of the firm’s cash flows (X). Outside board members will earn no reputation benefits if the final cash flows from the project equal zero. The reputation benefits can be motivated by good reputation as monitors, which will help outside directors obtain future directorships in other firms. At time 2, the expected benefits of reputation to outside board members are:

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3 Supporting the fact that firm value affects the utility of board members, Harford (2000) shows that directors of firms that are taken over have difficulty finding a replacement board seat. Harford also finds that among poorly performing firms, directors that rebuff a takeover offer have fewer future directorships, suggesting that firm performance affects outside board member wealth. Gilson (1990) finds that when a firm files for bankruptcy, only 46% of directors retain their seats. Gilson also finds that the number of seats held by any director who sits on other boards decreases for directors who resign from financially troubled firms. Kaplan and Reishus (1990) find that senior managers of firms that cut dividends tend to get fewer directorships in other firms.
\[ E(\text{Reputation Benefit}) = (1 - \Phi_p) \mu X \]  

(4)

where \( \mu \) is a positive constant, since the value of reputation does not have to equal to firm value. I note that the expected reputation benefits decrease on \( \Phi_p \), the probability of failure of the proposed project. The value of reputation can depend on how much visibility the firm has in the market (more visibility might increase the amount of reputation for a director). This depends on the size of the firm projects (measured by \( X \)), and on the market interest in the firm (measured by \( \mu \)). For example, outsiders might earn higher reputation benefit from small firms that have a lot of market visibility because of expected future earnings. In this case, the value of \( \mu \) should be large.

Outside board members do not know the probability of failure of the bad project, and they do not know which of the two projects the CEO proposed. Outsiders have the option of verifying the probability of failure of the proposed project before voting. I assume that it is necessary for outside board members to verify that the CEO proposed the bad project in order for them to reject the project. This can be justified by the need to produce verifiable information that will support the outsiders’ decision to vote against the CEO.

Verification is costly, and outsiders solicit the probability of failure of the proposed project (\( \Phi_p \)) from insiders before deciding whether to verify the information. Outsiders use their succession votes as an incentive for insiders to reveal their information. Part C in this section describes the succession voting rules.

I assume that verification costs will be prohibitive if no insider reveals the true probability of failure of the proposed project because outsiders receive no assistance and it is difficult to generate information when firm insiders have an incentive to conceal it. If at least one insider reveals the true probability of failure, verification costs per outside board member equal a fixed cost of observing the information, \( \Psi \), plus coordination and communication costs that increase with the number of outsiders on the board.

Let the coordination and communication costs equal \( C \). Equation (5) shows the verification costs per outside board member:

\[ \text{Verification Cost} = \Psi + C m \]  

(5)
Note $\Psi$ does not decrease with the number of outsiders on the board, so monitoring costs increase linearly in $m$. However, monitoring costs need not do so. The results do not change significantly with any other monotonically increasing function. I can derive similar results when monitoring costs increase only after some fixed $m^{\psi}$.

All outsiders vote in favor of the proposed project if they decide not to verify its probability of failure. All outsiders also vote in favor of the proposed project if they verify its probability of failure and find that the CEO proposed the good project, and they vote against the proposed project if they verify that the CEO proposed the bad project (if they verify that $\Phi_p > 0$).

2. Insiders: There are “n” identical insiders on the board, excluding the CEO. The insiders compete with each other to become the CEO’s successor and each insider has the same ex-ante probability of succeeding the CEO. Each insider decides whether to reveal the true probability of failure of the proposed project to the board. I refer to revealing the true probability of failure of the proposed project as informing the board. Remaining silent is equivalent to declaring that the CEO proposed the good project.

The incentives of the inside board members are distorted. Each insider can earn a private benefit equal to $B$ from remaining silent when the CEO proposes the bad project if the board approves it and the project has a good outcome (outcome X) at time 3. These private benefits to the insider come in addition to the benefits that the CEO receives from the bad project. All insiders who remain silent earn private benefits from the bad project regardless of the number of insiders on the board. All insiders are fired if the final cash flows from the project equal 0.

C. Succession Voting Rules

The entrepreneur sets up a rule under which outsiders vote on the CEO successor choice. The rule is designed to provide incentives for insiders to inform the board and assist in the implementation of the good project.

All the outside board members vote for the same insider based on the succession voting rules. The CEO votes for an insider of his choice. I assume that each inside board member votes

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4 For example, most of my results hold if I assume that outsiders divide the fixed verification costs among themselves, so that Verification Costs=$[\Psi/m] + Cm$. In this case, verification costs are increasing on $m \geq \sqrt[\Psi]{C}$. 

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for himself, so only the votes of the CEO and the outside board members count. Further, I assume that if there is only one outsider on the board, then the vote of the outside board member prevails over the CEO’s vote for successor. Figure 3 at the end of the paper illustrates the full tree with all the outcomes and the utilities of the players in the game. Figure 2 at the end of this section provides a reduced version of the tree.

I use (I) as the set of insiders who reveal the true failure rate of the proposed project to outsiders, and let (N-I) be the set of insiders who remain silent. All players in the game find out which insiders belong to set (I) and which insiders are in set (N-I) when the project is implemented at time 2.

First, I consider the case in which outsiders verify the probability of failure of the proposed project ($\Phi_p$). In this case, outsiders reward the insiders in (I) by selecting one insider in that set to receive all their votes, so that each insider in (I) has a $1/|I|$ chance of getting all the outside succession votes. $|I|$ refers to the number of insiders in the set (I). Outside board members select someone from outside the firm for CEO if the set (I) is empty. The insiders in (N-I) receive no votes for succession but are allowed to keep their current jobs.

Second, outsiders may decide not to verify the information provided by (I). In this case, all outsiders vote in favor of the proposed project without verifying the information given by (I). They make the succession decision based on the final project outcome.

If the final outcome is X, all the outsiders vote for the successor chosen by the current CEO. The CEO selects one successor from the set (N-I), so each insider in that set has a $1/(|N-I|)$ chance of becoming the next CEO. $|N-I|$ refers to the number of insiders in the set (N-I). The CEO nominates someone from outside the firm if the set (N-I) is empty. The CEO fires all insiders in (I). If the final outcome equals zero, external monitors fire the CEO and all the firm insiders (including the members in (I)).

Note that there is no incentive for insiders to reveal a false positive probability of failure of the proposed project because outsiders will not be able to verify the information since verification costs will be prohibitive. In this case, outsiders will vote along with the CEO for both project choice and successor choice. The CEO fires all insiders who informed the board that the probability of failure of the proposed project is positive.

Figure 2 shows part of the extended form tree of the game in the case in which the CEO proposes the bad project to the board.
II. Analysis of the Board

The decision of insiders to inform the board and the decision of outsiders to verify the information provided by insiders are interrelated. I first study the incentives of the outside board members, depending on the number of insiders who inform the board and the probability of failure of the proposed project. Next, the inside board members make their decision to inform the board based on the expected response of the outsiders and the probability of failure of the proposed project. These results are used in determining the value added by boards and the optimal board structure.
A. The Outside Board Members’ Decision to Verify Project Failure Rate

There are no benefits to outsiders from verifying the probability of failure of the proposed project when all insiders remain silent, since either no insider revealed the truth (in which case monitoring costs are prohibitive), or the CEO proposed the good project. When all insiders remain silent, the outsiders do not verify the project quality and the project gets board approval.

Outsiders decide whether to verify the probability of failure of the proposed project when one or more insiders inform the board that the CEO proposed a project with a positive probability of failure. Outsiders decide based on their expected benefits, which they can obtain if they are able to reject the bad project and replace it with the good project.

Definition 2: Let $\tau$ be the minimum number of insiders who must reveal their information to the board and vote with outsiders to reject the bad project such that outsiders plus $\tau$ constitute a majority on the board. $\tau$ is greater than or equal to one, since at least one insider must inform the board in order for outsiders to consider monitoring the project.

Equation (6) defines $\tau$. Note that I add the CEO’s vote in favor of the bad project when deriving the value of $\tau$.

$$\tau + m = n + 1 - \tau + 1$$

$$\tau = \text{Max} \left[ \frac{n - m}{2} + 1, 1 \right]$$

Lemma 1: Outside board members will not verify the probability of failure of the proposed project if less than $\tau$ insiders reveal the true probability of failure of the proposed project ($\Phi_p$).

Proof: Outsiders cannot expect to reject the bad project if less than $\tau$ insiders reveal the truth since a majority voting is necessary in order to reject the proposed project. There are no benefits of reputation to justify the monitoring costs to outsiders.

Note that $\tau$ measures the ability of outsiders to implement their project choice. Outside board members have the information necessary for verifying the project quality after one insider reveals his private information, but outsiders need the support of $\tau$ insiders to implement the good project. The lower the proportion of outsiders on the board, the higher the value of $\tau$. 
The net expected benefit to each outside board members from verifying the probability of failure of the proposed project when \( \tau \) or more insiders reveal that the probability of failure equals \( \Phi_p \) is:

\[
E(\text{Reputation Benefit} / \Phi_p) = \mu X - \mu (1 - \Phi_p) X = \mu \Phi_p X
\]  

(7)

**Proposition 1:** Outside board members verify the information provided by insiders if and only if at least \( \tau \) insiders inform the board and the probability of failure of the proposed project is greater than \( \Phi_m \), where \( \Phi_m \) is defined as follows:

\[
\Phi_m = \frac{C_m}{\mu X} + \frac{\Psi}{\mu X}
\]

(8)

Proof: See Appendix.

Lemma 1 establishes that at least \( \tau \) insiders must inform the board in order for outsiders to monitor. In addition, outsiders will monitor if the net expected benefits are greater than the monitoring costs. This gives rise to \( \Phi_m \) as the minimum cutoff that makes the expected benefits larger than the monitoring costs.

**Corollary 1:** Outsiders become less willing to verify the project type as their number on the board increases.

Proof: See appendix

The minimum cutoff failure probability (\( \Phi_m \)) for outsiders to verify the project type increases with the number of outsiders on the board. This is due to the increase in the coordination and communication costs as the number of outsiders on the board increases.

**B. Insiders’ Decision to Reveal Project Failure Rate**

In addition to the utility of becoming the CEO and the expected private benefits from the bad project, each insider’s decision to reveal information depends on the insider’s expectation of how many other insiders will reveal their information; the minimum cutoff failure rate of the proposed project necessary for outsiders to monitor (value of \( \Phi_m \)); and the actual probability of failure of the proposed project.
Let \( W(k) \) be the utility of an insider who discloses the true probability of failure of the proposed project to the board when he expects \( k \) other insiders to inform the board. Let \( S(k) \) be the utility of an insider who remains silent when he expects \( k \) insiders to inform the board. The utility of an insider who is fired equals zero. The utility of receiving no promotion in the firm is \( U(NP) \), the utility of becoming the future CEO is \([ R \times U(NP)]\), and the additional utility from private benefits is \([ B \times U(NP)]\), where \( R \) is greater than one, and \( B \) is greater than zero for the bad project and \( B \) is equal to 0 for the good project. The utility of an insider when he informs the board and his utility when he remains silent depend on the succession voting rules described in part C of section I.

If an insider reveals the true probability of failure of the proposed project along with \( k \) other insiders, the insider has a \( 1/(k+1) \) chance of becoming the future CEO of the firm if the board verifies the information. However, the insider will be fired if the outsiders do not verify the information.

If an insider chooses to remain silent and \( k \) insiders reveal the probability of failure of the project, he has a \( 1/(n-k) \) chance of becoming the CEO if the outsiders do not verify the information provided by the \( k \) insiders and the project succeeds. Further, the insider also receives a private benefit from the bad project if the project succeeds. The project succeeds with a probability \( (1-\Phi_p) \). However, if the \( k \) insiders who reveal are able to trigger verification, the insider who remained silent is able to keep his current job but has no chance of becoming the future CEO. Equations (9) and (10) define \( W(k) \) and \( S(k) \), respectively:

\[
W(k) = \left( P(\text{Ver})_k \left[ \frac{R \times U(NP)}{k+1} + \left( 1 - \frac{1}{k+1} \right) U(NP) \right] \right) + (1 - P(\text{Ver})_k) \times 0 \quad (9)
\]

\[
S(k) = P(\text{Ver})_k \times U(NP) + \left( (1 - P(\text{Ver})_k) \times (1 - \Phi_p) \left[ \frac{R \times U(NP)}{n-k} + \left( 1 - \frac{1}{n-k} \right) U(NP) + (B \times U(NP)) \right] \right) \quad (10)
\]

\( P(\text{Ver})_k \) is the probability that outsiders verify the information and implement the good project, given that \( k \) insiders reveal. \((1 - P(\text{Ver})_k)\) is the probability that outsiders do not verify the information, given that \( k \) insiders reveal.
I note that the utility of an insider who informs the board when outsiders decide to verify the information decreases on k (of course, as indicated by Lemma 1, k needs to be at least equal to \( \tau \) for outsiders to even consider the possibility of verifying the information). This is because the larger the number of insiders who reveal the probability of failure of the proposed project, the lower the probability of each revealing insider becoming the future CEO.

In the case in which the outsiders do not verify the information, the utility of an insider from remaining silent increases as the number of insiders who inform the board increases. This is because the board goes along with the successor choice of the CEO, and the CEO selects a successor from the set of insiders who remain silent. A higher number of insiders who inform the board implies less competition for the insiders who remain silent.

Since all insiders work together, I assume that insiders can communicate with each other and among their subsets to decide whether to reveal the probability of failure of the proposed project. Therefore, in solving for the decision of insiders to reveal their information to the board, I allow them to make decisions individually as well as in credible groups. Credibility requires that no subset of insiders within the group will benefit from deviating further from the group. In solving the problem, I use a reduced simultaneous game among the insiders taking into account the response of the outside board members.

I use the “Coalition-Proof Nash Equilibrium” (CPNE) refinement of the Nash equilibrium to solve for the decision of the inside board members. This concept is discussed in Bernheim Peleg and Whinston (1987) and Bernheim and Whinston (1987). The refinement states that a given point is a CPNE if no credible coalition of players can form that will be better off if it deviates from the equilibrium.

**Lemma 3:** All the firm insiders remain silent if the probability of failure of the proposed project, \( \Phi_p \), is less than or equal to the minimum required probability of failure of the project for outsiders to be willing to verify the information. (i.e. \( \Phi_p \leq \Phi_m \))

Proof: Based on the succession-voting rule, all the insiders who reveal a positive probability of failure of the proposed project will be fired if outsiders do not verify the information.

I first present the Nash Equilibrium results for this game (which does not allow insiders to communicate and form coalitions), and then discuss the conditions under which a given equilibrium satisfies CPNE.
**Proposition 2**: There are exactly two pure strategy Nash Equilibria in this game:

A. All insiders inform the board

B. No insider informs the board

Proof: See Appendix.

Intuitively, each individual insider prefers to inform the board if all other insiders inform because outsiders are expected to verify the information and reward those who informed the board. No insider prefers to inform if no one else informs the board and the insider alone is not able to trigger verification by informing the outsiders. If the board does not verify the probability of failure of the proposed project, only the insiders who remain silent are awarded by the CEO.

I now consider the conditions necessary for a given equilibrium to be CPNE. Note that lemma 3 applies even when insiders are allowed to communicate and form coalitions. In the case where the probability of failure of the proposed project is larger than $\Phi_m$, I have two candidate equilibria points: “all insiders inform” and “no insider informs.”

**Proposition 3:**

A) “All insiders inform” is the only CPNE if and only if $W(\tau-1) > S(k), k=0,\ldots, \tau - 1$.

B) “No insider informs” is the only CPNE if and only if $W(k) \leq S(\tau-1), k=(\tau-1), \tau\ldots(n-1)$

Proof: See Appendix.

If a set of insiders that is large enough to trigger monitoring always prefers to inform the board regardless of the number of insiders who remain silent, then all insiders know that a set will inform the board and monitoring will take place. Therefore, all insiders prefer to inform the board and get a chance to become the CEO’s successor. Note that it is sufficient to consider whether a set of $\tau$ insiders are better off informing the board, while others remain silent, because this set has a maximum utility from informing the board. $W(\tau-1)$ is the utility of each insider who informs the board when only $\tau$ insiders inform.

If a set of insiders that is large enough to prevent monitoring (so less then $\tau$ insiders are left informing the board) prefers to not inform the board regardless of the number of insiders who inform the board, then all insiders know that enough insiders will remain silent that monitoring will not take place. Therefore, no insider informs the board. Note that it I sufficient to
consider whether a set of \((n-\tau-1)\) insiders are better off remaining silent, while others inform the board, because this set benefits the most from not informing the board. \(S(\tau-1)\) is the utility of each insider who remains silent when only \((\tau-1)\) insiders inform the board.

**Corollary 2:** “All insiders reveal” is the only CPNE if and only if \(W(\tau-1) > S(\tau-1)\)

“No insiders reveal” is the only CPNE if the condition does not hold.

Proof: I note that \(S(k)\) increases in \(k\) when outsiders do not monitor, because \((n-k)\) insiders compete to become the CEO. Therefore, \(S(\tau-1) > S(\tau-2) > \ldots > S(0)\), which means that it is sufficient for \(W(\tau-1) > S(\tau-1)\) for condition A of proposition 3 to be satisfied. Similarly, \(W(k)\) decreases on \(k\) if outsiders monitor, because \((k+1)\) insiders reveal and compete to become CEO. Therefore, \(W(\tau-1) > W(\tau) \ldots > W(n-1)\), which means that it is sufficient for \(S(\tau-1) \geq W(\tau-1)\) for part B of proposition 3 to hold.

Interestingly, corollary 2 implies that it is sufficient to consider whether each member of a group of \(\tau\) insiders is better off informing the board while all other insider remain silent, or whether it pays for one of the members to deviate further from the group and remain silent to prevent monitoring. This also means that a Coalition Proof Nash Equilibrium always exists for this game.

Proposition 4 considers the minimum project probability of failure necessary for insiders to inform the board.

**Proposition 4:** Inside board members will reveal the probability of failure of the proposed project to the board if the probability of failure is large enough to induce outsiders to monitor \(\left(\Phi_p > \Phi_m\right)\) and if it is larger than \(\Phi_n\) where:

\[
\Phi_n = 1 - \frac{(R + \tau - 1)(n - \tau + 1)}{\tau[R + B + ((B + 1)(n - \tau))]}
\]  

(11)

Proof: See appendix.

I compare \(W(\tau-1)\) with \(S(\tau-1)\) to derive \(\Phi_n\).

I note that although the private benefits from the bad project make the bad project look more attractive, the bad project’s higher probability of failure also increases the risks of the insiders getting fired. When \(\tau\) insiders consider revealing the probability of failure of the project
to the board, they take into account their higher chances of becoming the future CEO due to lower competition, as well as the good project’s lower probability of failure.

**Corollary 3:** All else constant, inside board members become more willing to inform as their number on the board increases ($\Phi_n$ decreases in $n$). Insiders become less willing to inform the board as the minimum number of insiders that must inform to trigger monitoring increases ($\Phi_n$ increases in $\tau$).

Proof: See appendix.

Intuitively, insiders become more willing to inform the board as their number on the board increases because of the higher competition to become the CEO. Insiders become less willing to inform the board as more insider are needed to support the outsiders in voting against the bad project because the chance for each individual in $\tau$ to become the CEO of the firm decreases with $\tau$ (each member gets a $1/\tau$ chance to become the CEO).

**C. Firm Value Under the Corporate Board**

The board will reject the bad project and implement the good project whenever the CEO proposes a project with a probability of failure that is greater than both $\Phi_n$, the minimum cutoff at which insiders are willing to inform the board, and $\Phi_m$, the minimum cutoff at which outsiders are willing to verify the information on the project. Let $\text{Max}(\Phi_n, \Phi_m) = \Phi_{\text{Max}}$. The board approves the project if the CEO proposes a project with a probability of failure less than $\Phi_{\text{Max}}$. I use equation (3) to derive the value of the firm under the investment policy $[\Phi_{\text{Max}}]$.

$$V(\Phi_{\text{Max}}) = \left[1 - \frac{\Phi_{\text{Max}}^2}{2}\right]X \quad \quad (12)$$

Figure 4 (see Appendix) graphs the contribution of the board to shareholder value, assuming that the agency problem in the firm is severe enough so that CEO’s preferred investment policy $[\Phi_{\text{CEO}}]$ require a higher minimum cutoff of failure of the bad than the investment policy preferred the board $[\Phi_{\text{Max}}]$. Note that the expected value of the firm increases as $\Phi_{\text{Max}}$ decreases. The value added to shareholders with a corporate board is:
\[ V(\text{Board}) = \left( \frac{\Phi_{\text{CEO}}^2 - \Phi_{\text{Max}}^2}{2} \right) X \]  

(13)

D. The Optimal Board

The goal in finding the optimal board structure hinges on considering the effects of the board structure in the willingness of insiders to inform the board and the willingness of outsiders to verify the information. Both, the number of insiders and outsiders on the board, as well as the proportion of outsiders and insiders affect the incentives of the board members.

I derive the optimal number of insiders \((n^*)\) and the optimal number of outsiders \((m^*)\) that minimizes \(\Phi_{\text{Max}}\), the minimum cutoff failure of the proposed project at which the board intervenes. To solve the problem, I substitute \(m\) as a function of \(n\) and \(\tau\), and find the optimal number of insiders \((n^*)\) and the optimal minimum needed defectors \((\tau^*)\), subject to the required constraint. I use \(n^*\) and \(\tau^*\) to derive \(m^*\).

Equation (6), in the analysis of the outside board members defines \(\tau\) and its relationship with \(n\) and \(m\) (the number of insiders and outsiders, respectively). I rewrite the equation as a function of \(m\):

\[ m = n + 2 - 2\tau \]

(14)

Equation (14) has the restriction that \(\tau \geq 1\) and that \(m > 0\). This means that \(\tau > \text{Max}[(n/2) + 1, 1]\), because the model requires at least one outsider on the board and we need at least one insider to inform the board. \[\square\]

I use two-step optimization in order to determine \(n^*\) and \(\tau^*\). The first part finds \(n^*(\tau)\) and the second part minimizes \(\Phi_{\text{Max}}(n^*(\tau), \tau)\) to find \(\tau^*\).

Proposition 5: For a given \(\tau\), the optimal \(n\) (equal to \(n^*\)) is at \(\Phi_m = \Phi_n\)

Proof: See Appendix.

For a given \(\tau\), \(\Phi_n\) decreases in \(n\) and \(\Phi_m\) increases in \(n\).

\[^5\text{No outsider on the board is the same as one in which the CEO makes all the project and succession decisions.}\]
The value for \( n^\ast \) is a solution for a quadratic equation. In this equation, I consider only the positive solution for the equation, since \( n^\ast \) must be positive. The solution is derived in the Appendix.

\[
n^\ast(\tau) = \frac{-b + \sqrt{(b)^2 - 4(a)(c)}}{2a}
\] (15)

where,

\[
a = \frac{C\tau(B+1)}{\mu X}
\] (16)

\[
b = \left( \frac{C\tau[R + B + (B+1)(2 - 3\tau)]}{\mu X} + \frac{\Psi\tau(B+1)}{\mu X} + (R - B\tau - 1) \right)
\] (17)

\[
c = \frac{\tau C(2 - 2\tau)(R + B - \tau(B+1))}{\mu X} + \frac{\Psi\tau(R - \tau + B(1-\tau))}{\mu X} + ( -\tau(R - 1) - (1 - \tau)(B\tau - R + 1))
\] (18)

**Lemma 4:** \( \hat{\tau} \) satisfies \( \frac{dn^\ast(\tau)}{d\tau} = 2 \). If \( 1 \leq \hat{\tau} \leq \frac{n+2}{2} \), then \( \hat{\tau} = \tau^\ast \), the optimal value of \( \tau \). If \( \hat{\tau} < 1 \), then \( \tau^\ast = 1 \). If \( \hat{\tau} > \frac{n+2}{2} \), then \( \tau^\ast = \frac{n+2}{2} \).

Proof: See appendix.

**Proposition 6:** Let \( \Phi(n^\ast, m^\ast) \) be defined as \( \Phi^\ast \).

The investment policy \([\Phi^\ast]\) maximizes the value of the firm under the corporate board and the corporate board rules as defined in the model.
Proof: $\Phi(n^*, m^*) = \text{Min } \Phi(n, m)$ for all the possible corporate board size and composition solutions. Equation (3) derives the value of the firm under an investment policy [$\Phi'$], where the value of the firm is decreasing in $\Phi'$.

I note that the optimal corporate board minimizes the residual agency problem but does not resolve it completely, since it is not necessary that $\Phi^*$ be equal to 0.

III. CEO Influence Over Outside Board Members

In the previous sections I have examined a corporate board of directors where the CEO has no influence over the outside board members. However, the empirical literature often defines some board members as gray board members. These board members can be viewed as outside board members who have closer ties to the CEO (for example, the CEO of another firm) which makes them more likely to be influenced by the CEO, but they bring knowledge that helps improve the overall board efficiency and decrease project verification costs to the board.

In order to bring the results of this paper closer to data, I allow the CEO to influence a fraction $p$ of the outside board members to vote for his project choice, even after the outsiders verify that the CEO proposed the bad project to the board. I assume that that $p$ is positive and that $0.5 < p \leq 1$, so that the CEO cannot influence more than half of the outside board members.

In terms of the succession voting rules, I assume that all outside board members vote according to the voting rules as described in section C of the Model. Further, the expected utility that outsiders receive from being influenced by the CEO to vote along with his project choice is not large enough for outsiders to verify the project failure rate when they don’t expect to be able to reject the bad project.

Allowing the CEO to influence the outside board members does not change the propositions of this paper significantly. The value of $\tau$ needs to take into account the fact that a $p$ proportion of outside board members is expected to vote with the CEO. Therefore, equation (6) becomes,

$$\tau + pm = n + 1 - \tau + (1-p)m + 1$$

$$\tau = \text{Max} \left[ \frac{n - (2p - 1)m}{2} + 1, 1 \right]$$

(19)

For simplification, $(2p - 1)$ equal $o(\beta)$. Solving for $n^*(\tau)$ I find:
\[
\begin{aligned}
n^*(\tau) &= -b + \frac{\sqrt{(b^2 - 4ac)}}{2a} \quad \text{(20)} \\
\end{aligned}
\]

where,
\[
\begin{aligned}
a &= \frac{C\tau(B + 1) - \mu X}{\mu X} \quad \text{(21)} \\
b &= \left( \frac{C\tau[R + B + (B + 1)(2 - 3\tau)] + \alpha(\beta)\Psi \tau(B + 1)}{\mu X} + \alpha(\beta)(R - B\tau - 1) \right) \quad \text{(22)} \\
c &= \frac{\tau C(2 - 2\tau)(R + B - \tau(B + 1)) + \alpha(\beta)\Psi \tau(R - \tau + B(1 - \tau))}{\mu X} + \alpha(\beta)(-\tau(R - 1) - (1 - \tau)(B\tau - R + 1)) \quad \text{(23)} \\
\end{aligned}
\]

Lemma 4 (the value of \(\tau^*\)) remains the same, and I use equation (19) to derive \(m^*\).

### IV. Comparative Statics

Changes in firm characteristics affect the incentives of the inside and outside board members, resulting in different optimal board size and composition. The effectiveness of the optimal corporate board is also affected by the firm characteristics. In this section, I consider the effects of two firm characteristics on the corporate board, the verification costs to outside board members and the private benefits that insiders can obtain from inferior projects.

Verification costs refer to the difficulty that outside board members have in verifying the information regarding the value of the projects in the firm relative to the benefits of reputation that they expect to obtain from implementing superior projects. The information asymmetry of the firm projects should influence the verification costs to outsiders. For example, verification costs should be higher for firms in the high tech industry, firms in less homogeneous industries (Parrino, 1997), and firms with high growth opportunities. In addition, proxies for the difficulty of the market in evaluating the firm are also measures of information asymmetry. An example of such a proxy is the dispersion in the analysts’ forecasts of the items in the income statement of the firm.

Private benefits refer to the likelihood that insiders will go along with inferior projects that the CEO prefers. For example, firms with large amounts of free cash flow (Jensen, 1986)
and firms where the CEO is the firm founder may generate large control benefits for the incumbent managers and may be more likely to have insiders favoring the pet projects of the CEO.

**Proposition 6:**

i) Firms optimally require a majority of outsiders on the board at low levels of monitoring costs and they optimally require a majority of insiders on the board at high levels of monitoring costs.

ii) The optimal number of outsiders on the board decreases with monitoring costs.

iii) For a given level of reputation benefits from the firm value (µX), the optimal number of insiders on the board decreases with monitoring costs up to Ψo. The optimal number of insiders on the board increases as monitoring costs increase for Ψ > Ψo, where Ψ represents the fixed costs incurred by outsiders from verifying the value of the project proposed by the CEO when at least one insider informs the board.

iv) Board size decreases with monitoring costs if Ψ < Ψo

v) The residual agency cost in the firm even with the optimal board structure increases as the monitoring costs from the bad project in the firm increase.

The incentives of outsiders to verify the information on the project decrease with verification costs (Φm increases with verification costs). Firms with higher levels of verification costs require a board that provide greater incentives for outsiders to verify the information. This is achieved by decreasing the number of outsiders, which decreases the coordination and communication costs among the outsiders and offsets part of the higher verification costs.

At very low levels of verification costs, optimal boards have a large number of inside and outside board members with outsiders having a majority on the board (τ* = 1). The large number of insiders on the board instills competition among the insiders while minimizing the board dependence on the insiders’ vote. As monitoring costs increase, the optimal number of outsiders on the board decreases. To maintain the voting power of the outside board members, the number of insiders on the board also decreases (τ* = 1 constrains) and board size decreases. This smaller board size provides higher incentives for outsiders to verify information on the project, but it comes at a cost of lower incentives for insiders to inform the board due to the lowered competition.
At very high levels of monitoring costs, the incentives for outsiders to monitor are very low. If fixed verification costs are larger than $\Psi_o$, the optimal number of insiders on the board increases with verification costs, while the number of outsiders on the board decreases, so that the optimal board has a higher proportion of insiders. In these firms, the higher competition among the insiders for the CEO succession and the fear that the bad project will fail leads the insiders to help implement the good project.

Firms with higher verification cost have less effective optimal boards, as indicated by the higher residual agency cost. The necessary changes to increase the incentives of outsiders to verify the information on the project choice come at a cost of the board depending more on the support of the insiders. Note that since firms with low verification costs require a majority proportion of outsiders on the board and firms with high verification costs require a majority of insiders on the board, this result suggests that it is possible to find that firms with a higher proportion of outsiders have more effective corporate boards. However, that does not mean that adding more outsiders to the board of a firm with higher verification costs would make the board more effective.\footnote{The empirical literature on corporate boards has studied the effectiveness of board of directors in performing functions that are considered to add value for shareholders (Weisbach (1988), Borokhovich, Parrino and Trapani (1996), Cotter, Shivdasani and Zenner (1997)). This is consistent with my result that firms with low monitoring costs optimally have a majority of outsiders on the board. However, in cross-sectional data, the finding that boards with a larger proportion of outsiders perform better may be driven by the fact that firms with low monitoring costs, that optimally need a majority of outsiders also have more effective optimal boards.}

Figures 5 graphs the optimal board structure against changes in the fixed verification costs of the firm’s projects ($\Psi$). Figure 6 graphs the residual agency cost from the optimal board structure for a given level of fixed verification costs. The results in the graph take the proposed extension into account, where the CEO influences a proportion $p$ of the outside board members.
**Figure 5:** Illustrates the changes in the optimal number of insiders ($n^*$), the optimal number of outsiders ($m^*$), and the optimal board size with changes in the fixed costs of verification of project quality. The utility of insiders from getting a promotion in the firm is assumed to equal two times the utility of not getting a promotion ($R = 2$). The expected utility of insiders from taking the bad project and ending up in the good state without a promotion is assumed to be 60% higher than the utility of an insider from not getting a promotion and taking the good project ($B = 0.6$). The CEO is able to influence 40% of the outside board members to vote in favor of his project choice ($p = 0.6$). The cost to outsiders in coordinating their actions is assumed to equal 1% of their benefits of reputation from firm value ($C/\mu X = 0.01$).

![Graph showing changes in optimal board size with verification costs.](image)

**Figure 6:** Increases in fixed verification costs and the effectiveness of the optimal board. Board effectiveness is measured by $\Phi^*$, which is the minimum cutoff failure rate of the bad project that triggers monitoring by the corporate board that is optimal for the given level of verification costs. A higher value of $\Phi^*$ means that the optimal board is less effective in monitoring management. The utility of insiders from getting a promotion in the firm is assumed to equal two times the utility of not getting a promotion ($R = 2$). The expected utility of insiders from taking the bad project and ending up in the good state without a promotion is assumed to be 60% higher than the utility of an insider from not getting a promotion and taking the good project ($B = 0.6$). The CEO is able to influence 40% of the outside board members to vote in favor of his project choice ($p = 0.6$). The cost to outsiders in coordinating their actions is assumed to equal 1% of their benefits of reputation from firm value ($C/\mu X = 0.01$).

**Proposition 7:**

i) Firms optimally require a majority of insiders on the board at low levels of private benefits and they optimally require a majority of outsiders on the board at high levels of private benefits.

ii) The optimal number of outsiders on the board increases with private benefits.

iii) The optimal number of insiders on the board decreases as private benefits increase up to $B_o$. The optimal number of insiders on the board increases as private benefits increase for $B > B_o$, where $B$ represents the amount of private benefits in the firm.
iv) Board size increases with private benefits if $B > B_o$.

v) The residual agency cost in the firm even with the optimal board structure increases as the potential private benefits from the bad project in the firm increase.

The incentives of insiders to inform the board decrease as their expected private benefits from the bad project increase ($\Phi_n$ increases with private benefits). Firms with a higher level of private benefits require a board that provides greater incentives for insiders to inform the board. This is achieved by either increasing the number of insiders on the board while maintaining the outside voting power (increase in competition) or by increasing the proportion of outsiders on the board (lower $\tau$).

At very low levels of private benefits, insiders’ incentive to inform and assist the board in implementing the good project is high. In this case, it is more efficient to have a large proportion of insiders on the board and save on the coordination costs of the outside board members ($\tau^*>1$). As private benefits increase, it is optimal to increase the voting power of the outsiders by decreasing the number of insiders on the board and increasing the number of outsiders (decrease $\tau^*$). This change in the board structure provides more incentives for insiders to inform the board, but it comes at a cost of higher coordination costs among the outsiders.

At $B_o$, the optimal board composition is such that outsiders have a majority on the board and only one insider needs to inform the board to trigger monitoring ($\tau^*=1$ constrains). If private benefits from the bad project are larger than $B_o$, then the optimal board requires a larger number of both insiders and outsiders. As a result, the size of the corporate board increases with expected private benefits but the voting power of the outside board members does not change ($\tau^*=1$ constrains). The higher number of insiders increases the competition among the insiders and their incentives to inform the board, but it comes at a cost of increased coordination costs among the outside board members.

Firms with higher private benefits have less effective optimal boards, as indicated by the higher residual agency cost. The necessary changes to increase the incentives of insiders to inform the board come at a cost of higher coordination costs to outside board members. Note that in the region where outside board members have a majority voting power ($\tau^*=1$ constraints), this result implies that firms that optimally require a larger board size have less effective optimal boards even though the larger board is the most effective board for that firm. This result may
partially explain why firms with smaller boards seem to have more effective corporate boards (Yermack (1996)). Further the corporate board may not be an effective monitoring mechanism for the firms with very high levels of private benefits and alternative mechanisms such as compensation may play a larger role in monitoring the managers of the firm.

Figure 7 graphs the optimal board structure against changes in firm private benefits (B). Figure 8 graphs the effect of changes in private benefits on the residual agency cost from the optimal board structure for the given level of private benefits. The results in the graph take the proposed extension into account, where the CEO influences a proportion \( p \) of the outside board members.

![Graph illustrating the changes in the optimal number of insiders (n*), the optimal number of outsiders (m*), and the optimal board size with changes in private benefits to the inside board members. The utility of insiders from getting a promotion in the firm is assumed to equal two times the utility of not getting a promotion (\( R = 2 \)). The CEO is able to influence 40% of the outside board members to vote in favor of his project choice (\( p(\beta) = 0.6 \)). The fixed cost of monitoring to outside board members is assumed to equal to 20% of the benefits of reputation that they receive from the value of the firm under the good project implementation (\( \Psi/\mu X = 0.2 \)). The coordination and communication costs to outsiders increase by 1% of their benefits of reputation with each additional outside board member (\( C/\mu X = 0.01 \)).](image_url)
Figure 8: Increases in private benefits and the residual agency cost of the optimal board. Board effectiveness is measured by \( \Phi^* \), which is the minimum cutoff failure rate of the bad project that triggers monitoring by the corporate board that is optimal for the given level of private benefits. A higher the value of \( \Phi^* \) means that the optimal board is less effective in monitoring management.

V. Conclusion

This paper explicitly models the interaction of inside and outside members of a corporate board. I study how different combinations of insiders and outsiders affect the monitoring ability of corporate boards. In doing so, I address an area of controversy – whether the size and the composition of a corporate board affect the value of the firm. I derive the board structure that maximizes the value of the firm, and study how the structure of the optimal board varies with firm characteristics.

Two functions of the board are considered in this paper, monitoring of projects in the firm and the selection of upper level management. Outside board members are motivated by their reputation in the market for outside directors but they are not fully informed regarding the specifics of the projects in the firm. Outsiders use their succession votes to motivate insiders to reveal their information to the board. The competition among insiders to become the CEO successor and the risks involved in undertaking an inferior project motivate insiders to inform outside board members and assist in the implementation of superior projects.

In addition to deriving the size and the composition of the board that maximizes the value of the firm, I also study the effectiveness of the corporate board as a monitoring mechanism for the particular firm characteristics. The optimal board structure and the effectiveness of the board
vary with the firm characteristics. I find that the corporate board is a very effective monitoring mechanism for some firms, for example firms where verification costs of firm projects are relatively small. However, in certain types of firms (firms with high verification costs to outsiders and firms with high potential private benefits to insiders) the board is not an effective monitoring mechanism.

In this paper, I focus on the corporate board as a monitoring mechanism. However, in general, several alternative mechanisms will play a role in controlling the agency problem studied. Direct monitoring by external claimants (e.g. banks and large institutional investors) or external monitoring mechanisms (e.g. takeover market) or managerial contracts (e.g. compensation contracts) are some alternative mechanisms that curtail the agency problems in the firm. To the extent that these mechanisms are effective, the reliance on corporate boards is reduced. However, when alternative monitoring mechanisms are not able to solve the agency problem completely, the corporate board has the advantage of being able to monitor the managers based private information that comes before the project choice is made. Most alternative mechanisms monitor based on the outcomes from the project. An interesting extension of this paper would be to study the interaction of the different monitoring mechanisms, i.e. the issue of complements versus substitute mechanisms and the effectiveness of one mechanism over the others.

In the process of studying the corporate board, this paper highlights the role that senior level management play in monitoring the firm. The senior insiders are motivated by the possibility of becoming the future CEO of the firm. A natural extension of this paper is to study how to compensate the senior level managers in such a way to increase their incentives to inform the board.
Variables used in the Model:

\[ X = \text{Final cash flows under the good state} \]
\[ \Phi = \text{Probability of failure of the bad project} \]
\[ \beta = \text{Private benefits that the CEO receives from bad project} \]
\[ U_{\text{ceo}} = \text{Utility of the CEO from keeping his current job} \]
\[ \Phi_{\text{ceo}} = \text{Minimum failure rate of the bad project for the CEO to prefer the good project} \]
\[ \Phi_p = \text{The probability of failure of the project proposed to the board} \]
\[ n = \text{Number of insiders in the board in addition to the CEO} \]
\[ m = \text{Number of outsiders in the board} \]
\[ \Psi = \text{Fixed costs of monitoring incurred by all outside board members} \]
\[ C = \text{Communication and coordination costs to outside board members} \]
\[ 1-p = \text{Probability that the CEO will be able to influence outsiders to favor his project choice even if outsiders know that the CEO chose the bad project} \]
\[ o = 2p - 1 \]
\[ \tau = \text{Minimum number of insiders so that } (\tau + p(\beta)m) \text{ constitutes a majority in the board} \]
\[ R = \text{Utility of becoming the CEO} \]
\[ B = \text{Private benefits that insiders n receive from bad project} \]
\[ \mu = \text{Constant fraction used to define the reputation benefits of monitoring} \]
\[ \Phi_m = \text{Minimum failure rate of the bad project for outsiders to prefer monitoring} \]
\[ \Phi_n = \text{Minimum failure rate of the bad project for } \tau \text{ insiders to prefer to inform outsiders} \]
\[ n^* = \text{Optimal number of insiders on the board} \]
\[ m^* = \text{Optimal number of outsiders on the board} \]
\[ \tau^* = \text{Optimal number of the minimum insiders that must inform the board to trigger monitoring} \]
\[ \Phi^* = \text{The minimum failure rate of the bad project for the optimal board to monitor the bad project.} \]
Figure 3: Succession and Project Decision of the Board. The structure of the decision of the corporate board members

CEO observes $\Phi$ and chooses between the
good project and the bad project

Bad project

Each Insider decides whether to
reveal the value $\Phi$ of the bad project

I insiders reveal $\Phi$
N-I remain silent

Insiders remain silent

Outsiders decide whether to monitor

Monitor

N promotion
I promotion
N-I no promotion
m (benefits-cost)

I fired
N-I fired
m no returns

1-$\Phi_p$

n no promotion
m (benefits-cost)

n fired
m no returns

1 -$\Phi_p$

CEO observes $\Phi$ and chooses between the
good project and the bad project

Good project

Outsiders decide whether to monitor

Monitor

n promotion
m (benefits-cost)

n promotion
m benefits

Not Monitor

n promotion
m benefits

Not Monitor

n promotion
m benefits

M = all outsiders
N = all insiders
I = revealing insiders
Ver = verify $\Phi_p$
NVer = not verify $\Phi_p$
$\Phi_p$ = project probability of failure

7 For expositional clarity, certain branches of the tree have been pruned. For example, insiders actually face three choices: inform the true $\Phi$ to the board, remain silent, or inform a false value of $\Phi$ to the board. However, revealing a false value of $\Phi$ will not be taken in this game. I have ignored that branch in this tree.
Figure 4: VALUE ADDED BY A BOARD

- $\Phi$ is the probability that the bad project will fail. $\Phi \sim U(0,1]$
- The probability of failure of the good project is normalized to 0.
- The relevant cutoff points of $\Phi$, for the action of the different players:
  a. CEO prefers good implementation if $\Phi > \Phi_{\text{ceo}}$
  b. Outsiders willing to monitor if $\Phi > \Phi_{\text{outsiders}}$
  c. Insiders willing reveal their information if $\Phi > \Phi_{\text{insiders}}$

CEO prefers good project

Insiders willing to inform the board

Outsiders willing to monitor

Value added by the Corporate Board
References


Appendix

Proofs:

Proposition 1: Decision of outside board members to verify the probability of failure of the proposed project:
Outside board members will verify the probability of failure of the proposed project only if they expect their benefits from reputation to be higher than the verification costs. Therefore, the following condition must be satisfied:

\[
\mu \Phi > \Psi - (C m) > 0 \quad (A.1)
\]

\[
\Phi > \frac{C m}{\mu X} + \frac{\Psi}{\mu X} \quad (A.2)
\]

\(\Phi_m\) is the minimum cutoff such that (A.2) is satisfied.

Corollary 1
Equation (A.3) shows the relation between \(\Phi_m\) and \(m\):

\[
\frac{\partial \Phi_m}{\partial m} = \frac{C}{\mu X} > 0 \quad (A.3)
\]

The minimum cutoff \(\Phi_m\) increases with the number of outsiders on the board, implying that outsiders are less willing to monitor as their number on the board increases.

Proposition 2
Define:
\(W(k)=\) Utility of insider from revealing when \(k\) other insiders reveal
\(S(k)=\) Utility of insider from not revealing when \(k\) other insiders reveal

A. Assumptions:

Assumption 1: There is a higher utility for going along with the \(\tau\) majority on the board:

(A1) If at least \(\tau\) reveal \(\Phi\), then insider is better off revealing: if \(k \geq \tau\) \(W(k) > S(k)\)

(A2) If less than \((\tau - 1)\) reveal, then individual insider is better off not revealing: if \(k \leq \tau - 2\) \(W(k) < S(k)\)

No assumption on \(k = \tau - 1\)

Assumption 2: The decision to reveal depends on the utility of the insider number \(\tau\). BR refers to Best Response:

At \(k = \tau - 1\), if \(W(\tau - 1) > S(\tau - 1)\) then \(BR(i) = \) reveal.
if \(W(\tau - 1) \leq S(\tau - 1)\) then \(BR(i) = \) not to reveal.

B. Proofs:

Proposition 2:
There are exactly 2 Nash Equilibria:
i) **Everyone reveals**

ii) **No one reveals**

**Proof of theorem 1:** Only Assumption 1, (A1) and (A2) are required for the proof.

Suppose k of N\{i} have chosen to reveal. What is i’s best response (BR)?

- If k ≤ τ - 2, BR{i} = not reveal
- If k ≥ τ, BR{i} = reveal
- If k = τ - 1, BR{i} = reveal if W(τ - 1) > S(τ - 1) or BR{i} = not reveal if W(τ - 1) ≤ S(τ - 1)

Therefore, it is clear that no one revealing and every one revealing are Nash Equilibria (NE).

Are there other NE? No.

Suppose k reveal and (n-k) do not reveal

- **Case 1:** k ≤ τ - 2, each agent in the revealing group is better off switching to the not revealing group
- **Case 2:** k ≥ τ, each agent in the non revealing group is better of switching to revealing.
- **Case 3:** if k = τ - 1
  - a) if W(τ - 1) > S(τ - 1) then each agent in the non revealing group is better off revealing.
  - b) if W(τ - 1) ≤ S(τ - 1) then each agent in the revealing group is better off not revealing.

**Proposition 3:**

a) All insiders revealing is the only one CPNE if and only if W(τ - 1) > S(k), k = 0, ..., τ - 1.

b) No insider revealing is the only one CPNE if S(τ - 1) ≥ W(k), k = τ - 1, ..., n - 1.

**Proof of part a:**

Two conditions need to be satisfied for not CPNE:

a) There exists a coalition where each member of the coalition is better off in the proposed deviation.

b) There is no further credible sub-coalition deviation that will make the sub-coalition better off.

**Part I:**

First show that no one revealing is not CPNE:

1. **Step1:** Is each member of the coalition better off?
   - Suppose no one reveals. Consider a coalition of \{1, ..., τ\} ∈ A. If they deviate jointly, each i ∈ A: W(τ - 1) > S(0)
   - **Step2:** Is the coalition credible?
     - If a sub-coalition B ⊆ A deviates (back to not revealing Φ)
     - S(τ - |B|) < W(τ - 1)
   - No. Members of the sub-coalition cannot be made better off and they will go along with the coalition.
   - Therefore, no one revealing is not CPNE

**Part II:**

Second, show that all insiders revealing is CPNE. We demonstrate that no credible coalition will deviate from all insiders revealing.

Suppose every one reveals.

- Deviating coalition has k members, and the coalition has enough members to prevent monitoring.
- Therefore, k ≥ (n - τ + 1)

---

8 Note that these are all the possible groups that can prevent monitoring.
A coalition of k members is not credible because
\[ S(n-k) < W(\tau - 1) \text{ since } (n-k) < \tau. \]
This means that a sub-coalition of (\(\tau + k - n\)) members will be better off going back to revealing \(\Phi\), indicating that there is no credible deviating coalition and all insiders revealing is a CPNE.

All insiders revealing is the equilibrium only if the condition holds. Proof:
If \(W(\tau - 1) < S(k)\) \(k=0, .., \tau - 1\)
Then a credible coalition can form to prevent monitoring. Therefore all insiders revealing will not be an equilibrium.

Proof of part b:
All insiders revealing is not CPNE.

Part I:
If all insiders reveal \(\Phi\), a coalition of \(k=n-\tau+1\) can form to block monitoring and leaving \((\tau-1)\) revealing.
\[ \text{a) Each member is better off:} \quad W(n) \leq S(\tau - 1) \]
\[ \text{b) A further sub-coalition will not form:} \]
\[ \quad \text{Let sub-coalition } B \subseteq A \text{ deviate back to revealing.} \]
\[ \quad W(\tau - 1 + |B|) \leq S(\tau - 1) \]
Therefore, a sub-coalition will not form

Part II:
Show that no insider revealing is CPNE:
We demonstrate that no credible coalition will deviate from not revealing.
Deviating coalition has \(k\) members, \(k \geq \tau\)
A coalition of \(k\) members is not credible because a further sub-coalition will of \((k-\tau+1)\) will further deviate (not reveal \(\Phi\)), leaving \(\tau - 1\) to reveal:
\[ V(k) \leq S(\tau - 1) \]
Therefore, no credible coalition will deviate from no insider revealing \(\Phi\). Q.E.D.

Proposition 4

Deriving \(\Phi_n\):
The decision of insiders to reveal the probability of failure of the proposed project depend on the utility functions,
\[ W(\tau - 1) = \frac{RU(NP)}{\tau} + \left(1 - \frac{1}{\tau}\right)U(NP) \quad (A.3) \]
\[ S(\tau - 1) = (1-\Phi)\left(\frac{RU(NP)}{n(\tau - 1)} + \left(1 - \frac{1}{n(\tau - 1)}\right)U(NP) + BU(NP)\right) \quad (A.4) \]
\[
\frac{R}{\tau} + \left(1 - \frac{1}{\tau}\right) > (1-\Phi)\left(\frac{R}{n(\tau-1)} + \left(1 - \frac{1}{n(\tau-1)}\right) + B\right)
\]

\[
(1-\Phi) < \left(\frac{R + \tau - 1}{R + B + ((B+1)(n-\tau))}\right) \times \left(\frac{n - \tau + 1}{\tau}\right)
\]

\[
\Phi_n = 1 - \frac{(R + \tau - 1)(n - \tau + 1)}{\tau[R + B + ((B+1)(n - \tau))]} \quad (11)
\]

**Corollary 3:**

Equations (15) and (16) derive the partial derivatives for \(n\) and \(\tau\), respectively. The value of equation (15) is negative because \(R>1\), and the value of equation (16) is positive:

\[
\frac{\partial \Phi_n}{\partial n} = \frac{\tau (R + \tau - 1)(1 - R) - \tau^2 (R + B + (B + 1)(n - \tau)^2)}{\tau^2 (R + B + (B + 1)(n - \tau))^2} \quad (A.5)
\]

\[
\frac{\partial \Phi_n}{\partial \tau} = \frac{(R - 1)[(n - \tau + 1)(R + n - \tau + B n - B \tau + B) + (R + \tau - 1)(\tau)]}{\tau^2 [R + B + (B + 1)(n - \tau)]^2} > 0 \quad (A.6)
\]

**Proposition 5:** The optimal number of insiders is at \(\Phi_n=\Phi_m\)

**Proof:** Min[Max(\(\Phi_n,\Phi_m\))] is at \(\Phi_n=\Phi_m\)

We have seen that:

\[
\frac{d\Phi_n}{dn} < 0 \quad \quad \quad \quad \frac{d\Phi_m}{dn} > 0
\]

If \(\Phi_n>\Phi_m\), increases in \(n\) will decrease \(\Phi_n\) and cause \(\Phi_m\) to increase. Since Max(\(\Phi_n,\Phi_m\)) is equal to \(\Phi_n\), the maximum will go down.

If \(\Phi_m>\Phi_n\), decreases in \(n\) will decrease \(\Phi_m\) and increase \(\Phi_n\). Since Max(\(\Phi_n,\Phi_m\)) is equal to \(\Phi_m\), the maximum will go down.

Therefore, the Min[Max(\(\Phi_n,\Phi_m\))] is found at the point where \(\Phi_n=\Phi_m\). At this point, any changes in \(n\) will cause the Max(\(\Phi_n,\Phi_m\)) to go up.
Finding \( n^* \):

The text describes \( \Phi_n \) and \( \Phi_m \):

\[
\Phi_n = 1 - \frac{(R + \tau - 1)(n - \tau + 1)}{\tau [R + B + ((B + 1)(n - \tau))] + \tau (R - \tau + B(n - \tau + 1))}
\]

(A.7)

\[
\Phi_m = \frac{C + \Psi}{\mu X} + \frac{\mu}{\mu X}
\]

(8)

Substitute \( m = n + 2 - 2\tau \) in equation (5):

\[
\Phi_m = \frac{C (n + 2 - 2\tau) + \Psi}{\mu X} + \frac{\mu}{\mu X}
\]

(A.8)

\( n^* \) is found by (A.2)=(12)

\[
\left[ \tau (R - 1) + (n - \tau + 1)(B - R + 1) \right] = \left[ \frac{C(n + 2 - 2\tau) + \Psi}{\mu X} \right] \tau [R + B + (n - \tau)(B + 1)]
\]

\[
\frac{n^2 C \tau (B + 1)}{\mu X} + n \left( \frac{C \tau [R + B + (B + 1)(2 - 3\tau)]}{\mu X} + \frac{\Psi \tau (B + 1)}{\mu X} + (R - 1 - B\tau) \right) + \frac{\tau C(2 - 2\tau)(R + B - \tau)(B + 1)}{\mu X} + \frac{\Psi \tau (R - \tau + B(1 - \tau))}{\mu X} - [\tau (R - 1) + (1 - \tau)(B - R + 1)] = 0
\]

Therefore,

\[
n^*(\tau) = \frac{-b + \sqrt{(b)^2 - 4(a)(c)}}{2a}
\]

(15)

where,
\[ a = \frac{C \tau (B + 1)}{\mu X} \]  
\[ b = \left( \frac{C \tau [R + B + (B + 1)(2 - 3\tau)]}{\mu X} + \frac{\Psi \tau (B + 1)}{\mu X} + (R - 1 - B\tau) \right) \]  
\[ c = \frac{C \tau (2 - 2\tau)(R + B - \tau(B + 1))}{\mu X} + \frac{\Psi \tau (R - \tau + B(1 - \tau))}{\mu X} - [\tau(R - 1) + (1 - \tau)(B\tau - R + 1)] \]

Only the positive square root is considered since it can be shown that \(c < 0\) and \(a > 0\).
The requirement is that \(n^* > 0\):

\[ \sqrt{(b)^2 - 4(a)c} > \sqrt{(b)^2} = b \]

This implies that,

\[ \frac{b - \sqrt{(b)^2 - 4(a)c}}{2a} < 0 \]

\[ \frac{b + \sqrt{(b)^2 - 4(a)c}}{2a} > 0 \]

**Finding \(\tau^*\):**

\[ \Phi^* = \Phi_a(n^*(\tau), \tau) = \Phi_m(n^*(\tau), \tau) \]

\[ \text{Min} \quad \Phi^*(n^*(\tau), \tau) \rightarrow \text{Min} \quad \frac{C}{\mu X} \frac{\left( n^*(\tau) + 2 - 2\tau \right)}{2 - 2\tau} + \frac{\Psi}{\mu X} \]

subject to: \(\tau \geq 1\)

FOC if constraint not binding:

\[ \frac{C}{\mu X} \left( \frac{dn^*(\tau)}{d\tau} - 2 \right) = 0 \rightarrow \frac{dn^*(\tau)}{d\tau} = 2 \]
SOC: \[ \frac{C}{\mu X} \frac{\partial}{\partial \tau} \left( \frac{dn^*(\tau)}{d\tau} \right) \]

It can be shown that:

\[ \frac{\partial}{\partial \tau} \left( \frac{dn^*(\tau)}{d\tau} \right) > 0 \]  \hspace{1cm} (A.9)

Equation (A.9) shows that SOC is positive, which means that \[ \frac{dn^*}{d\tau} = 2 \] is the Min \( \Phi^* \)

Using \( \Phi_n(n^*(\tau), \tau) \),

\[ \frac{d\Phi_n(n^*(\tau), \tau)}{d\tau} = 0 \rightarrow \frac{d}{d\tau} \left[ \frac{\tau(R-1) + (n-\tau+1)(B\tau-R+1)}{\tau(R+B+(B+1)(n-\tau))} \right] = 0 \]

Solving implicitly for \[ \frac{dn^*}{d\tau} : \]

\[ \frac{dn^*}{d\tau} = \frac{(n^*+1)[R + n^* - 2\tau + B(n^*+1-2\tau)] + \tau(2+B)}{(R+\tau-1)(\tau)} = 2 \]  \hspace{1cm} (A.10)

Let \( \hat{\tau} \) satisfy \[ \frac{dn^*(\tau)}{d\tau} = 2 \).

If \[ 1 \leq \frac{n^*}{2} \], then \( \hat{\tau} = \tau^* \), the optimal value of \( \tau \). If \( \hat{\tau} < 1 \), then \( \tau^* = 1 \). If \( \hat{\tau} > \frac{n^*}{2} \), then \( \tau^* = \frac{n^*}{2} \).