Boardroom Dynamics and Firm Value

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Abstract

We analyze how board members communicate information within the boardroom and make decisions about projects presented by the CEO. In particular, we augment the existing research by concentrating on how intra-board relationships and possibly divergent board member incentives affect CEO behavior and board characteristics. The strategic interaction within the boardroom and between the board and CEO lend new insights into some previously unexplored determinants of optimal board structure and yields several testable hypotheses. Specifically, we find that reputation concerns may lead to some largely silent board members. In dynamic firm environments these board members act as endogenous call options on information, highlighting the value of board heterogeneity. Furthermore, we show board size affects the tradeoff between efficiency and quality in CEO-board decision making. This connection defines how various firm characteristics relate to optimal board size.

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1 INTRODUCTION

We consider the asymmetries, spillover effects, and quality-level of the information gathered by different types of board members as they attempt to advise the CEO on potential projects. We analyze how these factors, combined with possible differing attitudes of the individual board members, affect the final advice of the board to the CEO, the decisions of the board on proposed projects, and ultimately, the incentives of the CEO. We differentiate the members by experience, ability, and potential, imparting on the less experienced candidates career and reputation concerns. These discriminants affect not only the strength of the information generated by each board member, but also what information becomes public. The various information sets are not substitutes, nor completely independent and there may occur spillover effects. Before and during the information gathering and advising process, the CEO-board dynamics are also evolving. The relationship is a function of the CEO’s human capital investment decisions and project specific vetting standards, as well as the board’s information revelation protocols and project evaluation policies. This complex interaction is modeled as a multiplayer repeated game of indeterminate length, from which we extract a set of perfect Bayesian Nash equilibria predicting the behavior of each party.

We divide all the possible board compositions into three main categories: the small boards, the large boards, and the heterogeneous boards. These categories are a reflection not so much of who the members are, but rather how the members interact with each other and the CEO. The equilibrium predictions of the various board compositions provide intuition and insights for some of the empirical regularities and puzzles that have arisen in the boards literature. We find that the small board possesses few incentive misalignments, but does not give as good advice as a large board. The small board tends to be most suitable during high quality states (e.g. when the potential for human capital investment is high and CEO vetted projects have higher ex-ante probabilities of succeeding). The large board, not surprisingly, makes relatively safe decisions. However, it tends to over-reject project proposals, creates the most severe incentive problems for the CEO, and imposes an endogenous information coordination cost on the firm. Large boards are best during low quality states. Lastly, we consider the heterogeneous board - a board in which the various members are at different stages in their respective careers, and may possess differing abilities and incentives. Such a board may sometimes create the same incentive problems of the large board, and suffer from the same weak signaling of the small board, but it is also more adaptable. The major behavioral prediction of the heterogeneous board is that members may sometimes remain silent, choosing not to reveal their private information.\footnote{This theoretical finding is supported by the empirical survey of Lorsch and McIver (1989) which finds that 51\% of directors express feeling inhibited about speaking out in board meetings, with a significant percentage of board respondents citing intra-board interactions as the primary reason for silence.}

We show that the strategic revelation behavior of the “silent member” in heterogeneous boards represents an endogenous call
option on information that can be of particular value in dynamic situations (e.g. where market quality and investment potential in human capital are in flux), and may help explain the persistence of a market for potentially silent board members.

As the previous discussion indicates, no one type of board is best in all circumstances. Different situations bring out the strengths and weaknesses of the different boards. And by considering the dynamic and diverse settings within which firms operate, these results help one to simultaneously appreciate some of the seemingly incongruous or unexplained empirical facts of the current literature.

Over the past 20 years considerable attention has been devoted to the study of the role of boards and the composition of optimal board structure. Early empirical papers seeking to understand the value of boards in terms of size found negative correlations between various measures of firm performance and board size (Yermack (1996); Eisenberg et al. (1998)). Jensen (1993) argued that the coordination problems of a large board exacerbate inherent agency problems in the CEO-board interaction, and may lead to poor firm performance. Such an empirical regularity begs the question, why were there any large boards to begin with?

In more recent empirical work, Cheng (2008) demonstrated evidence that larger boards have lower variability in firm performance, reflecting broad beliefs of the mean nature of group decision making (Sah and Stiglitz (1986, 1991)). Theoretical attempts to formalize this include Baranchuk and Dybvig (2009) who develop a notion of “consensus” in board decision making. Linck et al. (2008) also find that “firms with high growth opportunities, high R&D expenditures, and high stock volatility are associated with smaller and less independent boards, while large firms have larger and more independent boards.” Interestingly, they find that their “evidence does not support the popular notion that smaller, more independent boards strictly dominate alternative board structures.” The empirical findings of Linck et al. (2008) set against the prior literature on board characteristics serves to demonstrate the inherent complexity of the issue of board optimality.

Attempts to reconcile the sometimes contradictory and ambiguous empirical literature have led theorists to refine their characterizations of board members, classifying them into categories such as insider / outsider, friendly / unfriendly, talented / untalented, to name a few. Early work such as Hermalin and Weisbach (1988, 1998) address the issue of board composition by considering how the CEO succession process, as well as the director-CEO bargaining process affects the presence of insiders and outsiders on the board. Similarly, Raheja (2005) develops a theory of board size by utilizing the insider-outsider characteristic of board members and incorporating these differences into a CEO succession and project monitoring  

3 Although it remains to be seen how such behavior may be justified as a strategic game-theoretic solution concept played out by the individual board members. (cf. Adams et al., 2010)
Adams and Ferreira (2007) and Harris and Raviv (2008) study the role of boards as advisors through the cheap-talk framework and investigate board friendliness, independence, and delegation. And in work related to our paper, Song and Thakor (2006) investigate how talent, ability, and career concerns affect the CEO's information disclosure policies and the board's investment recommendations. The resulting analysis of these various board members and their relationship with and effects on the CEO, in particular how they monitor the CEO, have contributed to not only a deeper theory of boards, but also a more proper perspective with which to view empirical work.

However, a strong debate on the optimal composition and size of boards persists. The work of Boone et al. (2007) is telling. In the paper, an empirical analysis of board size and independence is performed across firms and over time against growth, monitoring, and managerial characteristics of the firm. While they find that board size and independence increase as firms grow and diversify, they concede “even considering all three hypotheses together, however, our empirical tests leave much of the cross-sectional variation in board size and composition unexplained. Thus, while economic hypotheses help explain board structure, there remains a large idiosyncratic or unexplained component to board structure.”

Part of the problem is that major character attributes like size and independence remain largely stationary within an immediate to intermediate time-frame, while many aspects of the firm’s operations, such as the specific nature of the firm’s current projects that determine some of the empirical measures of firm value (e.g. Tobin’s Q) against which the aforementioned board characteristics are often regressed, can be quite fluid. Implied in this discrepancy is a need to better understand the more dynamic aspects of the board, in particular, the inner workings of the board and how it relates to the ultimate decision making processes of both the board itself and the CEO. This is an area that has been largely neglected, and yet its importance is clear. Adams et al. (2010) acknowledge “a robust understanding of the role of directors requires a better understanding of just what goes on in the boardroom.” Thus, it is imperative to gain some insight into the fluid nature of the intra-board dynamics of the firm.

Our paper contributes to and extends the boards literature by providing a theoretical framework with which to analyze the recent burgeoning empirical literature on director heterogeneity. Two recent investigations address the relation between board level heterogeneity and firm valuation, yet come to alternative conclusions. Knyazeva et al. (2009) find that heterogeneity in director industry expertise is associated with lower firm valuations, while Anderson et al. (2009) document that boards with higher levels of occupational and social heterogeneity are associated with valuation premiums. While this paper does not serve to reconcile the two seemingly incongruous findings, we provide a more subtle argument as to when differences in board member characteristics best suit the interests of the firm.
2 Model

We consider a three-period model in which a firm needs to vet, discuss and implement a project. The agents in this model are the CEO and individual board members.

Time $t = 1$: The Economic Environment

At the beginning, Nature fixes the state of the world which consists of a market environment indicator $\epsilon \in (0, 1)$ and a human capital parameter $K > 0$. $\epsilon$ is a general rating of those market characteristics that have firm-specific relevance. Its exact function is to parameterize the riskiness of potential projects. This will be explained in the subsequent Time $t = 2$ subsection. When $\epsilon$ is low, the market environment is said to be poor. Conversely, when $\epsilon$ is high, the market environment is said to be good. $K$ represents the CEO’s investment opportunities in human capital. This parameter will affect the types of projects the CEO can find and develop in the next time period.

Time $t = 2$: Selecting a Project

At time $t = 2$, the CEO and board work toward selecting and implementing a project. The CEO begins by vetting projects.

Project Space

A project can either succeed with some payoff $y \geq 1$ or fail with payoff 0. Thus, a project is characterized by its success payoff $y$. And the project space is $[1, \infty)$.

Project Vetting and Human Capital $K$

The vetting process entails the CEO repeatedly drawing projects from the project space until he receives one that has an acceptable success payoff $y$. It is during this vetting process that the human capital parameter $K$ comes into play. The default human capital level is set to 0. However, before each time the CEO draws, he can choose to upgrade his human capital to $K$ at personal cost $c$. If the CEO chooses the default human capital level, he draws a 1-project with probability 1. If the CEO chooses to upgrade, then he draws a $y$-project with probability $\frac{1}{K}e^{-\frac{1}{2}(y-1)}$.\(^4\) The CEO chooses a vetting rule, which is a function $V$ from the project space to the set of decisions: “reject” or “accept.” For any $y^* \geq 1$, a $y^*$-threshold vetting rule is one where a $y$-project is accepted if and only if $y \geq y^*$. We don’t require the CEO to follow threshold vetting rules, but it will be clear that in equilibrium the vetting rule of the CEO will always take on such a form.\(^5\)

\(^4\)Note, as $K$ decreases to 0, this distribution converges to the trivial distribution with all weight on 1.

\(^5\)Technically speaking, any vetting rule that is almost surely a threshold vetting rule can occur in equilibrium as well.
Project Viability and Assessments

After the CEO has selected a project to present to the board, there is a hidden random variable \( \theta \in \{g, b\} \) that is realized. \( \theta \) captures the viability of the project. \( g \) means there are at most some minor problems with the project - issues that can be resolved by the expertise of the board. These projects are viable and will eventually succeed. \( b \) means there are major problems with the project - issues that cannot be fixed by the board. These projects are not viable and will fail.

It is the board’s job to gather information about any potential problems with the project and to advise the CEO to take any necessary courses of action to remedy said problems. This will, in turn, produce private signal(s) correlated to \( \theta \) representing board members’ final assessments of the viability of the project. A private signal \( s \) takes values in the set \( \{0, 1, 2\} \). The element 0 means that the board has given the project a clean bill of health. The element 1 means that there remain some reservations about the project. The element of 2 means that there are still serious concerns about the project.

The Function of the Market Environment Indicator \( \epsilon \)

The market environment indicator \( \epsilon \), defined in the previous subsection, parameterizes the distribution of \( \theta \) as well as the conditional distributions of any signal \( s \) given \( \theta \). We make the following assumptions:

a. Good market environment produces viable projects: \( P(\theta = g | \epsilon) \) is increasing in \( \epsilon \) and \( \lim_{\epsilon \to 1} P(\theta = g | \epsilon) = 1, \lim_{\epsilon \to 0} P(\theta = g | \epsilon) = 0. \)

b. Better signals \( \Rightarrow \) project more likely to be viable: for all \( \epsilon \), \( \frac{P(s=0|g,\epsilon)}{P(s=1|g,\epsilon)} > \frac{P(s=1|b,\epsilon)}{P(s=2|b,\epsilon)} \).

c. There is always some nonvanishing level of uncertainty: As a function of \( \epsilon \), \( P(s = 1|g, \epsilon) \) is bounded away from 0

Let us now describe, in detail, the process of how individual board members generate signals about the project.

Board Members and Their Information Sets

The pool of candidate board members consists of two classes: mature and immature. Within each class, there are two types: strong and weak. A mature member’s type is publicly known. Such an individual may be considered to be someone with a proven track record or ability in the industry. An immature member’s type is not known to anyone. This potential board member can be considered to be someone younger and has seen recent success but has not built a definite career upon which one can properly assess ability (i.e. a young upstart entrepreneur). A member’s class and type determine his ability to make a final assessment of the project and generate a private signal.

Each member gathers an information set which eventually may help generate an
independent private signal $s$. There are two types of information sets: high quality and low quality. A high quality information set is defined to be one that is rich enough to generate, by itself, a private signal. Mature-strong members always generate high quality information sets. Therefore, mature-strong members can always make a final assessment of the project. A mature-weak member will sometimes generate a low quality information set. By definition, a low quality information set can produce a private signal only if someone else has generated a high quality information set. Let us provide some justification for this dependence assumption.

**The Benefits of Discussion**

There is a widespread idea that the CEO’s firm-specific knowledge helps the board help the CEO. There are also previous instances of this idea being put to use in theory. For example, Adams and Ferreira (2006) model an information dependence where the CEO must choose a parameter first before the board’s signal has any relevance. We posit a similar relationship exists between individual board members where the information provided by one member may have positive spillover effects on the information provided by another member. The idea behind this assumption is that board members do not work in isolation. If we are to truly think of the board’s advisory role as that of setting “strategy, corporate policies, overall direction, mission, vision” (Demb and Neubauer (1992)) or creating networks and connections (Finkelstein (1999)), then it stands to reason there are positive externalities between different information sets. For example, a board member from the auto industry sitting on GM’s board with both firm- and industry-specific knowledge relevant to the project at hand, may enhance the advice that a member from the petroleum industry may provide since the contemporaneous operations and productions in both industries are complementary and one industry’s information set may be a leading indicator of the other’s. Or consider a banking member from a lender bank who has intimate knowledge of the financial position (e.g. debt obligations) of the firm. Such a member may provide relevant financial information that may help all the other members formulate relevant strategy and avoid giving financially unfeasible advice. More generally, strategy setting is oftentimes a multilayered process with the nature of certain strategic elements being predicated on the specific realizations of strategic fundamentals, so that there is an inherent dependence of the quality of advice about secondary strategic actions on the soundness of the more basic strategic directions taken.

**Reputation Concerns**

A mature members has no reputation concerns since his type is publicly known.

Any mature member always knows the quality of his information set and that of any revealed information set. An immature member cannot discern the quality of an information set. Furthermore, an immature member, regardless of his type, will only sometimes produce a high quality information set. However, the imma-

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6Independence is not crucial to our predictions, but does make computations more clean.
ture member’s unknown type determines the probability of him generating a high quality information set. Thus, if the immature member reveals his information set, then any mature member will have a more precise posterior estimate of the immature member’s type. If the immature member is risk averse over his own type, then he will suffer an ex-ante cost of revelation.

Support for this construct comes from Fama and Jensen (1983), which posits the existence of a market for outside directors’ services: “Our hypothesis is that outside directors have incentives to develop reputations as experts in decision control” (p. 315).7 We do not explicitly model the reputation cost based on first principles, but rather assume that the immature member suffers a constant cost $\rho$ of revelation every time he reveals.8

**Summary of Information Structure**

<table>
<thead>
<tr>
<th>Information Quality</th>
<th>Private Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td>Low</td>
<td>No, unless there is another high quality information set</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Board member</th>
<th>Characteristics</th>
<th>Information Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature-strong</td>
<td>Public type, no reputation concerns, can discern information quality</td>
<td>High</td>
</tr>
<tr>
<td>Mature-weak</td>
<td>Public type, no reputation concerns, can discern information quality</td>
<td>High or low</td>
</tr>
<tr>
<td>Immature</td>
<td>Unknown type, reputation concerns, cannot discern information quality</td>
<td>High or low</td>
</tr>
</tbody>
</table>

**Board Types**

For simplicity, the board consists of either one or two members. We assume that any board always contains at least one mature-strong member. This effectively means there are three types of boards:

- Small, strong board consisting of a single mature-strong member. A single signal is produced.
- Large, strong board consisting of two mature members, at least one of which is strong. Two signals are produced.

7Yermack (2004) also discusses reputation concerns for outside directors. Furthermore, Gilson (1990) shows that for directors that resign, possibly due to poor reputation, following financial distress hold fewer board seats following the resignation.

8While an actual immature member’s cost of revelation may change over time, it is likely that as his type becomes more realized he will transition into a mature member and seek out the career opportunities afforded his particular type, becoming replaced by a new immature member. Thus, if the immature member of a board in this model represents an aggregation of actual immature members at various stages of their maturation, then we may assume that the characteristics of the immature member, including the cost of revelation, is largely constant over time.
• Heterogeneous board consisting of a mature-strong member and an immature member. Two signals are produced, but the immature member’s signal may remain hidden.

These choices allow us to formalize the career concerns that underly the immature members’ reputation concerns. A mature-strong member can sit on any of the three boards. A mature-weak member can only sit on a large-strong board as a subordinate to the other mature member who is of strong type.

The CEO-Board Game
We can now set down the rules for how a project is selected. In the time $t = 2$ game played by the CEO and the board, the CEO goes first and draws projects. Before each draw, the CEO selects a human capital level and a vetting rule. Once a project is drawn that meets the vetting standards of the CEO, it is presented to the board for approval. The board members gather their information sets and make final assessments of the project. These assessments are in the form of signals. Mature members, lacking any reputation concerns, are not strategic and reveal their signals. If there is an immature member, he observes this public information, and then makes a decision whether or not to reveal his own signal. Once the discussion is over, an approve or reject decision is made concerning the project. This choice is a function of the revealed signals. The holder of this decision right is a mature member - it doesn’t matter who, since the mature members have no conflicting interests. If the project is approved, the model moves to time $t = 3$. If the project is rejected, the game loops back to the CEO.

Time $t = 3$: Outcome and Payoffs
If the board accepts a project then the probability of the project succeeding is a function of the viability variable $\theta$. Recall, if $\theta = g$, the project succeeds. If the $\theta = b$, the project fails.

Preferences
Once a $y$-project’s outcome is realized at time $t = 3$, the CEO and shareholders receives utility $y$ if the project succeeds and 0 if it fails.\(^9\) If the project succeeds, each board member receives $b$ extra utils than what he would have received if the project failed.\(^10\) In prior time periods, all utilities are non-discounted expectations.

\(^9\)The shareholders’ utility function is still different from the CEO’s because shareholders do not suffer any human capital costs.

\(^10\)If is not necessary to define, specifically, what utilities board members receive when the project fails and when the project succeeds. The only quantity that matters for the analysis is the difference $b$. 

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3 EQUILIBRIUM DYNAMICS

3.1 THE SMALL-STRONG AND LARGE-STRONG BOARDS

Mature board members suffer no reputation costs and their utilities are purely functions of the success or failure of the project. Therefore, independent of the CEO’s vetting process, the board will approve a project only when the conditional probability of the project being viable is the highest. This occurs when all board members’ final assessments of the project are optimal (i.e. all signals equal to 0). Given the board’s stationary equilibrium behavior, it is clear the CEO will select the same threshold vetting rule and the same human capital level for each draw during his turn(s). Therefore, we have proved the following:

Lemma 1. Suppose the board is either a small-strong or a large-strong board. Then there is a unique Bayesian perfect equilibrium. In this equilibrium, the CEO employs a constant threshold vetting rule and human capital level, and the board approves the CEO presented project if and only if all the signals of the project are 0.

3.2 THE HETEROGENEOUS BOARD

Suppose the board consists of a mature-strong member and an immature member of unknown type. Note, if the mature-strong member’s signal is nonzero then he will reject the project no matter what is the immature member’s signal. Therefore, the immature member will speak up only if the mature-strong member’s signal is 0. So, suppose the mature-strong member’s signal is 0. For the immature member, the reputation cost associated with revealing is constant. However, his private estimate of the likelihood of the project being viable worsens as his own signal worsens. Therefore, if his silence is construed as tacit approval by the rest of the board, then the worse the immature member’s signal, the more important it is for him to speak up. One then expects that the immature member will employ a threshold revelation rule: speak up and reveal signal if and only if own signal is sufficiently bad and the mature-strong member’s signal is equal to 0.

So, suppose the immature member employs such a revelation rule. What is a best response for the mature-strong member? Notice, the highest conditional probability the mature-strong member will ever have of the project being viable is when the immature member is silent. Recall, the mature-strong member holds the decision rights of the board and he only cares about maximizing the probability of the project succeeding. Thus, on the equilibrium path, the board’s decision rule is: approve the CEO vetted project if and only if the immature member is silent and the mature-strong member’s signal is 0. One can then check that the best response of the immature member to such a decision rule of the board is to employ

11There may be multiple equilibria for the heterogeneous board. Thus, this expectation amounts to an equilibrium selection.
the type of threshold revelation rule described above. Therefore, we have proved the following:

**Lemma 2.** Suppose the board is a heterogeneous board. Then there is a Bayesian perfect equilibrium such that, on the equilibrium path, the CEO employs a constant threshold vetting rule and human capital level; the immature member employs a threshold revelation rule; and the board approves the CEO vetted project only when the mature-strong member’s signal is 0 and the immature member is silent.

### 4 Comparative Statics and Predictions

#### 4.1 Small-Strong Versus Large-Strong Boards

First consider the relative merits of the small-strong and large-strong boards with respect to the market environment indicator. We need to make a non-triviality assumption:

**Assumption 1.** For all sufficiently high market environments, the CEO will choose to upgrade human capital.

This assumption will hold as long as $K$ is sufficiently high or $c$ is sufficiently low.

As $\epsilon$ tends to one, approved projects succeed almost surely, regardless of which board is used. However, the large-strong board continues to reject projects at a consistently higher rate than the small-strong board. Thus there is a smaller incentive-misalignment between the small-strong board and the CEO than between the large-strong board and the CEO. Conversely, when $\epsilon$ is sufficiently low, the incentives of the CEO completely shut down regardless of board type. This is because it either takes too long for the board to approve a project or the approved project’s success likelihood is too low or both. Therefore, the CEO does not invest in human capital and just accepts the first drawn project from the trivial distribution. As a result, shareholder value is purely a function of which board produces better information.

**Lemma 3.** When the market environment is sufficiently good, the small-strong board dominates the large-strong board. When market environment is sufficiently poor, the large-strong board dominates the small-strong board.

Low $\epsilon$ implies that the CEO will always choose the default human capital level. However, depending on the other fundamentals, higher $\epsilon$ may lead to the CEO to upgrade to the higher human capital level. Thus Lemma 3 suggests:

**Prediction 1.** There is a negative correlation between board size and human capital investment.

We posit that the market environment indicator and the human capital parameters are correlated. Assume that $K$ is weakly increasing in $\epsilon$ and $c$ is weakly decreasing
in $\epsilon$. When $\epsilon$ and $K$ are high and $c$ is low, we say that the state of the firm is high. Conversely, when $\epsilon$ and $K$ are low and $c$ is high, we say the state of the firm is low. Then Lemma 3 generalizes to firms states:

**Corollary 1.** For sufficiently high firm states, the small-strong board dominates the large strong board. For sufficiently low firm states, the large-strong board dominates the small-strong board.

Of course, the state of the firm and firm performance are intrinsically correlated. Thus Corollary 1 implies:

**Prediction 2.** Board size and firm performance are negatively correlated.$^{12}$

### 4.2 Heterogeneous Versus Strong Boards

What happens to the dynamics of the heterogeneous board as the market environment indicator shifts upwards? As $\epsilon$ increases, projects become increasingly safe when all signals are $\leq 1$. Therefore, no matter the immature member’s reputation costs, for all sufficiently high $\epsilon$, the immature member will remain silent if his own signal is $\leq 1$. However, we stress that it is not true that the immature member, unambiguously, becomes completely silent for all sufficiently high $\epsilon$. There is no reason why the conditional probability of the project being not viable given that at least one signal is 2 cannot be bounded away from 0 for all $\epsilon$. If this is the case, then for all sufficiently high $b$ (the difference in utility for a board member between the project succeeding and failing), it is intuitive that the immature member will continue to speak up when his own signal equals 2 and the other signal is 0, no matter how large is $\epsilon$. Therefore, the heterogeneous board does not, necessarily, become isomorphic to the small-strong board when $\epsilon$ is large.

Nevertheless, the probability of $\theta = b$ becomes increasingly rare as $\epsilon$ increases. Thus, the small-strong and the heterogeneous board, on average, exhibit the same behavior as $\epsilon$ becomes large.

**Lemma 4.** For all sufficiently large $\epsilon$, the heterogeneous board does approximately as well as the small-strong board and, therefore, dominates the large-strong board.

As the market environment moves away from perfect, the immature board member will naturally tend to speak out more. Even if the immature board member does not change his revelation strategy, he will tend to speak out more simply because the likelihood of the bad state increases. But, of course, as the likelihood of the bad state increases, so does the likelihood of the mature-strong member receiving nonzero signals. Therefore, for lower values of $\epsilon$, it is unclear how the immature member will behave and how valuable the heterogeneous board will be.

Part of the reason for this ambiguity is because we have not restricted how the

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$^{12}$This corroborates the findings of Yermack (1996).
parameters $b$ and $\epsilon$ move together. Lemma 1 implies that changing $b$ does not affect the behavior of strong boards and therefore, does not affect CEO behavior or shareholder value. However, the size of $b$ does affect the immature board member’s incentives. As a result, the behavior and value of the heterogeneous board will change with $b$.

**Lemma 5.** For all sufficiently small $b$, the immature member will remain completely silent independent of the market environment. Fix the market environment, the immature member will speak out at least sometimes for all sufficiently high $b$.

When should one expect $b$ to be high? We posit that when the firm is distressed, the success of projects is particularly important for a board member. For example, project failure may lead to firm failure. This may then affect the job prospects of a board member. Indeed, he’s already out of at least one job now. Such career concerns ought to be particularly pronounced for immature board members. Conversely, when the market environment is high, the market for corporate governance shrinks and $b$ ought to be lower.

So, consider a $b$ that is decreasing in the market environment indicator. Suppose when the market environment is poor, $b$ is high enough that the immature member speaks out sometimes. Then, the probability of a heterogeneous board-approved project succeeding is higher than that of a small-strong board-approved project succeeding. Therefore, during poor market environments, the heterogeneous board dominates the small-strong board. Conversely, when the market environment is good, suppose $b$ is sufficiently low that the immature member is silent. Then, the heterogeneous board is isomorphic to a small-strong board and therefore, dominates the large-strong board.

Recall, earlier, we defined the notion of firm state as the market environment indicator plus some extra data about how human capital parameters move with the market environment. The above observations remain valid for firm states as well.

**Prediction 3.** The heterogeneous board tends to mimic the behavior of the more valuable strong board. Thus, the heterogeneous board is of particular value when the firm operates in a dynamic state, where parameters like the market environment, investment potential in human capital and human capital costs are in flux.

## 5 Applications

### 5.1 Information Suppression

A primary tension between the CEO and the board comes from the fact that the board does not internalize the vetting costs of the CEO. Thus, in equilibrium, CEO-accepted projects are susceptible to over-rejection by the board. For example, when the market environment $\epsilon$ is good, all signals equal to 1 is almost as
good as the best-case scenario - all signals equal to 0. Yet, Lemmas 1 and 2 imply that any board will reject a project that has generated only “1” signals. This creates a potentially significant incentive for the CEO to suppress information so as to increase the speed of the board approval process. We model information suppression by assuming that the CEO can, at some personal cost $H$, alter the conditional distribution of board members’ signals.

Let $P_s(i|\theta, \epsilon)$ be the probability, under suppressed information, that a signal takes value $i$ given viability $\theta$ and market environment $\epsilon$. Suppose $P_s(0|\theta, \epsilon) = \frac{1-P(0|\theta, \epsilon)}{2}$, $P_s(1|\theta, \epsilon) = \frac{P(1|\theta, \epsilon)}{2}$ and $P_s(2|\theta, \epsilon) = \frac{P(2|\theta, \epsilon)}{2}$. That is, the probability measures induced under suppressed information puts more weight on the event of the board finding nothing wrong with the project. This produces two important effects. The first effect is more rapid board approval of CEO presented project. This is a consequence of the fact that “0” signals occur more frequently. The second effect is less informative signals. This is a consequence of the fact that more of the “0” signals are being generated for non-viable projects.

**Lemma 6.** For both small-strong and large-strong boards, the CEO suppresses information when the market environment is sufficiently good if $H$ is not too high and does not suppress information when market environment is sufficiently poor no matter the value of $H$.

Of course, these results easily generalize to firm states as well. We emphasize, however, the CEO suppresses information during high states (or good market environments) not because of private benefit opportunities - although, one can easily include such a component in the model. Rather, the CEO suppresses information because he is aligned with shareholders, and wants to get a high-payoff project rolling before being exhausted by a board quibbling over largely insignificant details. Conversely, that the CEO does not suppress information during low states is not indicative of some idea that the stakes are high and that during tough times, everybody needs to stick together. In fact, it is because the CEO has no incentives, that there is no information suppression.

**Remark 1.** Even allowing for information suppression, the small-strong board continues to dominate the large-strong board when the state is high and the large-strong board continues to dominate the small-strong board when the state is low. Moreover, the heterogeneous board continues to mimic the behavior of the more valuable strong board, and therefore, remains a valuable option when the firm operates in a dynamic state.

### 5.2 Activist Boards

We can model a more proactive board by assuming that the board influences the viability of a project. Specifically, let us assume that if the firm has a large-strong board, then the viability probability given the market environment upgrades from
\(P(\theta|\epsilon)\) to \(P_a(\theta|\epsilon)\) where

\[
1 > P_a(\theta = g|\epsilon) > P(\theta = g|\epsilon) \text{ for all } \epsilon
\]

while all the conditional probabilities of the signals remain unchanged,

\[
P_a(s|\theta, \epsilon) = P(s|\theta, \epsilon)
\]

**Remark 2.** Even with a more active board, Lemma 3 continues to hold. That is, when the market environment is sufficiently good, the small-strong board dominates the large-strong board. When market environment is sufficiently poor, the large-strong board dominates the small-strong board.

This is easy to see. When the market environment is good, \(P_a\) is not much better than \(P\), but the disadvantages of the large-strong board in the original model still persist - the large-strong board still rejects projects more often than the small-strong board. Conversely, when the market environment is poor, the large-strong board was already better than the small-strong board in the original model. Therefore, the large-strong board is even more attractive in the new model.

In certain cases, each board member’s job is narrowly defined. The strategy he helps set may be well-quantified, and the advice he gives may be of a technical nature. Examples include the boards of tech firms or specialized financial firms. In such cases, as the firm expands, the cost of information gathering may also cease to be low (or zero as we have stylized in this model). Indeed, when the cost of information gathering is sufficiently high, the equilibrium board decision strategy will be “always approve,” regardless of board type. In this case, it is clear the ranking of the boards is determined by the success probability. The model then predicts a trend to greater board size.\(^\text{13}\)

**Lemma 7.** Suppose each board member incurs an effort cost \(e\) every time the CEO presents a project for the board to consider. For all sufficiently high \(e\), the large-strong board dominates the small-strong board.

### 5.3 Recent Empirical Investigations

Recently, various authors have made attempts to quantify different aspects of board heterogeneity (social, expertise, occupational) and investigate its determinants and relation to firm valuation.\(^\text{14}\) Controlling for endogeneity concerns, Anderson et al. (2009) find that boards with higher levels of social and occupational heterogeneity are associated with valuation premiums. In a similar study, Knyazeva et al. (2009)

\(^{13}\)Such a finding partially reflects the scope of operations hypothesis: firms with disparate businesses or firms with complex structures should benefit from constructing a board with more outsiders with a range of expertise, resulting in larger, more independent boards (Boone et al. (2007); Coles et al. (2008); Linck et al. (2008)).

\(^{14}\)Our study into heterogeneity most simply mimics the idea of social heterogeneity (age), but may also aptly apply to industry expertise heterogeneity on the board.
find that heterogeneity in director industry expertise is associated with lower firm valuation levels. The predictions of our model indicate that board heterogeneity is neither categorically a value enhancing feature, nor a value destroying feature - hence, it is no great surprise that different empirical findings may persist given different dataset constructions. The approach taken in this investigation offers a more nuanced perspective on the issue of board heterogeneity, detailing the value of heterogeneity when market conditions are in flux. Similar to recent work concerning the state dependent value of large boards and independent directors (Coles et al. (2008)), a transaction cost framework may yield a cross-sectional relation between board heterogeneity and valuation, conditioned on firm-state or market characteristics. If firms cannot alter the composition of their boards in a continuous manner, then one may observe that in times of a more dynamic environment, firms with more heterogeneous boards are outperforming those with less heterogeneous boards. Our work serves as a template to motivate further empirical research into the value of heterogeneous boards.

6 Conclusion

We have sought to understand board behavior both as a product of the strategic interaction between board members and as a response to the board’s dynamic relationship with the CEO. Specifically, we explore how individual board member characteristics such as strength and reputation concerns affect intra-board dynamics. We then determine how these dynamics influence not only the quality of advice provided by the board and the degree to which the interests of the board are aligned with that of the CEO, but also the equilibrium behavior of the board, and ultimately, the value of the board.

We identify three types of optimal board compositions, characterized by their distinct equilibrium behaviors and indirectly, by the distinct behaviors they induce in the CEO. We find that small boards make quicker decisions and tend not to over-reject CEO projects. Such boards are optimal during high firm states when it is important for the board to not interfere with the CEO. Large boards make safer decisions, but at the expense of incentive misalignment between the board and the CEO. During low economic states when caution is crucial, these boards are optimal. Finally, there is a class of heterogeneous boards which possesses intra-board incentive misalignments. We find that in such boards, reputation concerns cause certain members to remain silent. The strategic silence of these members is sensitive to the state of the firm, and implies that the heterogeneous board is more adaptable and potentially more valuable than other board compositions during uncertain times.

15 Coles et al. (2008) demonstrate that complex firms with larger boards, and R&D intensive firms with more insiders are associated with higher valuation levels. The underlying logic follows from the notion that boards cannot transition completely to their optimal form at any point in time and hence boards with particular features may be valued higher at given points in time.
Overall, our findings shed light on and address a number of irregularities identified in the empirical literature. Our model explains the existence of a market for silent members, the inherent value of heterogeneity in boards, and the persistence of large boards, despite findings that imply a negative correlation between board size and firm performance.

7 Appendix

Proof of Lemma 3. Let $s_1, s_2$ be signals. Assumptions$^{16}$ a and c imply

$$
\epsilon \to 1 \Rightarrow P(\theta = g|\epsilon) \to 1 \text{ and } P(s_i = 1|g, \epsilon) \text{ remains bounded away from } 0
$$

Therefore

$$
\epsilon \to 1 \Rightarrow P(\theta = g|s_i = 1, \epsilon) \to 1
$$

Then Assumption b implies

$$
\epsilon \to 1 \Rightarrow P(\theta = g|s_i = 0, \epsilon) \to 1
$$

Signal independence then implies

$$
\epsilon \to 1 \Rightarrow P(\theta = g|s_1, s_2 = 1, \epsilon) \to 1 \text{ and } P(\theta = g|s_1, s_2 = 0, \epsilon) \to 1
$$

Therefore, approved projects by the small- and large-strong both will most likely succeed. However, Assumption c implies

$$
\epsilon \to 1 \Rightarrow P(s_i = 0|g, \epsilon) > 0 \Rightarrow P(s_1, s_2 = 0|g, \epsilon) < P(s_i = 0|g, \epsilon) < 1 \quad (1)
$$

Suppose the CEO upgrades human capital and chooses a $y$-threshold vetting rule. Then his utility, facing a small strong board, is

$$
E[\text{project payoff}] \cdot P(\theta = g|s_i = 0, \epsilon) - E[\text{number of draws}] \cdot c \Rightarrow 
$$

CEO utility is

$$
K + y - \frac{ce^\frac{1}{K}(y-1)}{P(s_i = 0|g, \epsilon)} \text{ as } \epsilon \to 1
$$

So, as $\epsilon \to 1$, the CEO’s utility, facing a small-strong board, approaches

$$
\max_{y \geq 1} K + y - \frac{ce^\frac{1}{K}(y-1)}{P(s_i = 0|g, \epsilon)}
$$

Similarly, as $\epsilon \to 1$, the CEO’s utility, facing a large-strong board, approaches

$$
\max_{y \geq 1} K + y - \frac{ce^\frac{1}{K}(y-1)}{P(s_i, s_2 = 0|g, \epsilon)}
$$

$^{16}$Recall, we made three assumptions about the distributions of the viability parameter and board member signals.
Equation (1) clearly implies

\[
\arg \max_{y \geq 1} K + y - \frac{ce^K(y-1)}{P(s_i = 0|g, \epsilon)} > \arg \max_{y \geq 1} K + y - \frac{ce^K(y-1)}{P(s_1, s_2 = 0|g, \epsilon)}
\]

Since shareholders’ utility is simply \(K + y\), therefore shareholders strictly prefer small-strong boards over large strong boards for all sufficiently good market environments.

Let us now look at the case when the market environment becomes sufficiently poor. Suppose,

\[
\epsilon \to 0 \Rightarrow P(s = 0|b, \epsilon) \to 0
\]

Then

\[
\epsilon \to 0 \Rightarrow P(s_i = 0|\epsilon) \text{ and } P(s_1, s_2 = 0|\epsilon) \to 0
\]

This means that, under either a small- or a large-strong board, the CEO will suffer arbitrarily large losses as \(\epsilon \to 0\) if he chooses the upgrade human capital strategy. Therefore, the CEO chooses the default human capital level.

If, instead,

\[
\epsilon \to 0 \Rightarrow P(s = 0|b, \epsilon) \text{ remains bounded away from 0}
\]

Then Assumption a implies

\[
\epsilon \to 0 \Rightarrow P(\theta = g|s_i = 0, \epsilon) \text{ and } P(\theta = g|s_1, s_2 = 0, \epsilon) \to 0
\]

Again, the CEO will choose the default human capital level.

Thus, under either board, the success payoff will always be 1. But

\[
P(\theta = g|s_1, s_2 = 0, \epsilon) > P(\theta = g|s_i = 0, \epsilon) \text{ for all } \epsilon
\]

Therefore, the shareholders strictly prefer large-strong boards over small-strong boards.

Proof of Lemma 4. Let \(s_1\) be the signal of the mature-strong member, \(s_2\) be the signal of the immature member and \(s\) be a generic signal. Assumption c implies that as \(\epsilon \to 1\), the immature member will not speak up if \(s_1 = 0\) and \(s_2 = 0\) or 1. Suppose,

\[
\epsilon \to 1 \Rightarrow P(s = 2|g, \epsilon) \to 0
\]

Then, even if the immature member speaks up when \(s_1 = 0\) and \(s_2 = 2\), the board still rejects the same expected number of projects as a small-strong board, and the success probability of an approved project under either board is the same (as \(\epsilon \to 1\)). This is because the event where the immature member speaks up has vanishing probability as \(\epsilon \to 1\).
Suppose, instead,
\[ \epsilon \to 1 \Rightarrow P(s = 2|g, \epsilon) \text{ remains bounded away from 0} \]

But then
\[ \epsilon \to 1 \Rightarrow P(\theta = g|s_1 = 0, s_2 = 2, \epsilon) \to 1 \]

and the immature board member never speaks up for all sufficiently large \( \epsilon \). In this case, the heterogeneous board is isomorphic to the small-strong board. \( \square \)

**Proof of Lemma 5.** Let \( s_1 \) be the signal of the mature-strong member, \( s_2 \) be the signal of the immature member. If \( b < \rho \) then the immature member will never speak out. On the other hand, Assumption b implies that for all sufficiently high \( b \), the immature member will speak whenever \( s_1 = 0 \) and \( s_2 \neq 0 \). \( \square \)

**Proof of Lemma 6.** When \( \epsilon \to 0 \), the amount of the utility the CEO expects to receive from a project approaches 0. Therefore, he has no incentive to suppress information. Conversely, when \( \epsilon \to 1 \), suppressing information has a negligible effect on the success probability of an approved project, but does increase the probability of all signals equalling 0 by a nonvanishing amount, regardless of board type. This, in turn, decreases the number of draws the CEO has to make in the vetting process. Therefore, if \( H \) is not too high, the CEO suppresses information when the market environment is sufficiently good. \( \square \)

**Proof of Lemma 7.** Fix a small-strong or a large-strong board. The best possible scenario for the board to reject a project is when that project is not viable but the next project is viable and the board approves this subsequent project. In this case, the gain from rejection is \( b - e \). Thus, if \( e > b \), then the board will always approve the first project.

Facing a small-strong board, the CEO’s utility is
\[
\max \left\{ \frac{P(\theta = g|\epsilon)}{1 - \frac{K(y_s - 1)}{K + y_s - 1}} \right\}
\]

where
\[ y_s = \arg \max_{y \geq 1} \left( K + y \right) \frac{P(\theta = g|\epsilon)}{1 - \frac{K(y - 1)}{K + y - 1}} \]

Facing a large-strong board, the CEO’s utility is
\[
\max \left\{ \frac{P_a(\theta = g|\epsilon)}{1 - \frac{K(y_l - 1)}{K + y_l - 1}} \right\}
\]

where
\[ y_l = \arg \max_{y \geq 1} \left( K + y \right) \frac{P_a(\theta = g|\epsilon)}{1 - \frac{K(y - 1)}{K + y - 1}} \]

Since \( P_a(\theta = g|\epsilon) > P(\theta = g|\epsilon) \), therefore \( y_l \geq y_s \) and
\[
(K + y_l)P_a(\theta = g|\epsilon) > (K + y_s)P(\theta = g|\epsilon)
\] (2)
Clearly,
\[
P_a(\theta = g|\epsilon) > (K + y_l)P_a(\theta = g|\epsilon) - ce\frac{1}{K}(y_l - 1) \Rightarrow
\]
\[
P(\theta = g|\epsilon) > (K + y_s)P(\theta = g|\epsilon) - ce\frac{1}{K}(y_s - 1)
\] (3)

Suppose \( P_a(\theta = g|\epsilon) > (K + y_l)P_a(\theta = g|\epsilon) - ce\frac{1}{K}(y_l - 1) \). Then the shareholders’ utility with a large-strong board is \( P_a(\theta = g|\epsilon) \). Equation (3) then implies that the shareholders’ utility with a small-strong board is \( P(\theta = g|\epsilon) \). Therefore, large-strong dominates small-strong.

Suppose, instead,
\[
P_a(\theta = g|\epsilon) < (K + y_l)P_a(\theta = g|\epsilon) - ce\frac{1}{K}(y_l - 1)
\] (4)

Then the shareholders’ utility with a large-strong board is \( (K + y_l)P_a(\theta = g|\epsilon) \). Equation (4) plus
\[
(K + y_l)P_a(\theta = g|\epsilon) > (K + y_l)P_a(\theta = g|\epsilon) - ce\frac{1}{K}(y_l - 1)
\]
and
\[
P_a(\theta = g|\epsilon) > P(\theta = g|\epsilon)
\]
implies that
\[
(K + y_l)P_a(\theta = g|\epsilon) > P(\theta = g|\epsilon)
\]
This equation and Equation (2) imply that large-strong dominates small-strong.

\[\square\]

References


