Access, Common Agency, and Board Size*

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1. Introduction

The canonical view of the role of boards of directors is that boards monitor management and resolve agency problems between shareholders and management. Ensuring that the firm is run in the shareholders' interests is, in fact, the board's fiduciary duty. A large literature has studied the monitoring role of the board of directors and its associated impact on managerial incentives and firm performance.[1] However, this literature assumes that all directors on the board have a single, identical objective to maximize shareholder value. In this paper, we depart from this view of the board of directors and instead assume that directors have potentially different objectives and that their board membership confers to them the right to contract with the firms' executives. We show how this can arise in equilibrium and still be consistent with the fiduciary responsibility of board members to shareholders. We then examine how the size of a firm's board of directors impacts managerial incentives and firm performance. Specifically, we address two questions. First, does the size of the board of directors affect managerial incentives to increase shareholder value? Second, does board size affect shareholder value?

We propose that managerial incentives are determined in equilibrium, through optimal contracting between managers and a board of directors that potentially reflects multiple objectives. We begin by presenting a model where a risk-averse agent performs multiple tasks for a firm that is owned by a single shareholder. The shareholder has the sole right to direct the managers' actions. However, he can share this right by conferring contracting rights (board membership) to other parties that value access to directing managerial activites. The shareholder may prefer to provide this access to other parties because he directly benefits from assets that they own and bring within the firm if granted access to the manager (Rajan and Zingales (1998)). The shareholder and the other parties that are granted access to the manager are then multiple principals (the members of the board) who contract with a common agent (the manager) in a setting similar to the multi-task principal-agent model of Holmstrom and Milgrom (1991, 1987). Each principal encourages the manager to pursue activities that he values, and discourages her from performing tasks that the other principals value. We show that, in this setting, the agent's incentives are

[1] For recent surveys of this literature, see Hermalin and Weisbach (2001) and Bhagat and Black (1999). The original contributions to this literature come from Berle and Means (1932) and Jensen and Meckling (1976).

lower than would be had the contract been offered by a single principal. As a consequence, firm value is also lower.

Our view of what the board of directors does contrasts with the monitoring view prevalent in the literature. The monitoring view suggests that the primary role of the board of directors is to observe the actions taken by top management and intervene when necessary to resolve agency conflicts. Examples of this intervention are the hiring and firing of CEOs, approval or blockage of mergers and acquisitions, and implementation of restructuring plans.[2] While the evidence on board performance is mixed, if these activities are the primary function of the board, then it seems like boards do little in the vast majority of cases. In addition, it is not clear why firms need large boards or why there would be heterogeneity in board size if the primary function of the board is monitoring. While there is a presumption that board size and composition should have real effects on board monitoring, it is not obvious what this impact should be. A priori, larger boards may be more or less effective monitors than smaller boards. For example, larger boards may be better able to monitor because there are more observers of managerial actions. Conversely, free rider problems or greater disagreement or dissonance may imply that larger boards are less effective in monitoring. The upshot of this is that the relation between board size and board monitoring is unclear. Further, the empirical literature examining whether board size and composition have real effects on firm performance and managerial incentives shows mixed results.

There is also a view that the composition of the board is determined by top executives in order to allow those executives to extract rents from the firm. This "board capture" view suggests that contracting between the board and management is far from optimal from a shareholder value perspective (see Bebchuk, et al. (2002); Bertrand and Mullainathan (2001); Shleifer and Vishny (1989)). While there are certainly instances of board capture, it seems unlikely that board capture explains the size or the dynamics of the majority of boards (see Holmstrom and Kaplan (2003)). We discuss this in greater detail below.

We take the view that the function of the board is to establish firm objectives and contract with top management (the agent) about these objectives. As noted above, the canonical view is that the only firm-level objective is shareholder value maximization. However, firms or board members

[2] See for example Hermalin and Weisbach (1998), Weisbach (1988), Cotter, Shivdasani, and Zenner (1997), Byrd and Hickman (1992), Kini, Kracaw, and Mian (1995), Brickley, Coles, and Terry (1994) among others.

may also care about employees, the local community, the environment, pensioners, diversity in the workplace, or other objectives. As a result, these objectives are reflected in the way in which boards contract with top management. In other words, to the extent that boards reflect other concerns about firm activities, the nature of contracting between boards and management will be influenced by these concerns. How do parties reflecting multiple goals get to participate on the board of directors? We show that board participation is determined by a tradeoff between the value of assets that a party brings to the firm and the loss to shareholders resulting from the manager pursuing activities that this party values.

The notion of "other parties" apart from the shareholders in our model and the notion of stakeholders from the strategic management literature are closely related.[3] For example, Freeman and Reed (1983, p. 91), in one of the pioneering articles on stakeholder theory, define stakeholders as:

> Any identifiable group or individual who can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives. (Public interest groups, protest groups, government agencies, trade associations, competitors, unions, as well as employees, customer segments, shareowners, and others are stakeholders, in this sense.)[4]

Our definition of other interested parties is very similar, although we emphasize the importance of assets these other parties bring to the firm in addition to their interests in the firm's activities. We argue that the inability of external parties to write complete contracts over the firm's activities makes them value the ability to influence the firm's activities through representation on a firm's board of directors. Further, the inability of shareholders to write complete contracts with these other parties makes it efficient for the firm to offer these other parties board membership in exchange for their assets. Our theory endogenizes the composition of the board of directors, and so identifies which parties are sufficiently important to the firm to be included on the board.[5]

3 For a discussion of stakeholder theory, see Freeman and Reed (1983), Freeman and Evan (1990), Wheeler and Sillanpaa (1997), Post, Preston, and Sachs (2002), Freeman (1984), Muirhead, et.al., (2002), Kelly, Kelly, and Gamble (1997), Walker and Marr (2001), and Alkhafaji (1989).

4 For a similar definition in the business trade press, see Wheeler and Sillanpaa (1997).

5 At a perhaps more basic level, our theory is meant to be descriptive rather than normative. Our theory provides testable implications for how large the board of directors will be, how incentives will be determined for managers, and how firm performance will be affected given that there are multiple interested parties seeking board representation

There are several implications of our theory. First, our theory predicts that board size will be larger when there are more firm objectives. Second, the more separate principals there are (i.e., the larger the board size), the weaker the incentives are for stock price performance. This second prediction is the implication of common agency (see Bernheim and Whinston (1986) and Dixit (1996)). Third, the larger the board is and the weaker incentives are, the weaker is firm performance.

We test our model's predictions using a sample of 842 firms from the years 1998 to 2001 (2148 firm-year observations) from the S&P 500, S&P MidCap 400 and S&P SmallCap 600. We collect data on managerial incentives from Standard and Poor's ExecuComp dataset, and data on board composition from firms' proxy statement disclosures filed with the Securities and Exchange Commission. We supplement these data with firm performance data from Compustat. We also obtain data on firms' social objectives from KLD Research and Analytics Inc.'s Socrates database. This database contains information on the socially responsible goals pursued by S&P 500 and other firms. Our dataset allows us to isolate the relation between firm objectives, board size, managerial incentives, and firm performance. We measure firms' non-share price objectives using the KLD data. To measure managerial incentives we use the pay-performance sensitivity of the firm's top five officers. Our measure of firm performance is Tobin's Q.

Our empirical results are largely consistent with the predictions of our model. We first examine whether board size is correlated with multiple firm objectives as posited in our theory. We find that board size is positively associated with the number of a firm's socially responsible objectives reported in the Socrates database. We also find that board size is negatively related to managerial incentives. Further, managerial incentives are positively related to firm performance in both the levels and changes specifications. These results are consistent with Aggarwal and Samwick (2003a, c) and contrast with the results in Himmelberg, Hubbard, and Palia (1999), Morck, Shleifer, and Vishny (1988), and McConnell and Servaes (1990). Finally, we find that board size is negatively related to firm performance.[6] Our results are robust to the inclusion of various board and firm

in an environment of contractual incompleteness. Much of stakeholder theory is concerned with the normative questions of how firms should behave (e.g., sensitivity to the environment, diversity issues) and what firms should focus on (e.g., customer concerns, employee concerns) in the presence of multiple stakeholders. Because our focus is descriptive, we do not take a stand on whether a stakeholder orientation is better than a shareholder one.

6 See related evidence in Baysinger and Butler (1985), Hermalin and Weisbach (1991), Yermack (1996), Agrawal and Knoeber (1996), Klein (1998), and Bhagat and Black (2002).

control variables. We also estimate a structural model using three-stage least squares and find that our results are unaffected by the endogenous choice of board size. These results show that multiple firm objectives, through its effect on board size, have a significant negative relation with managerial incentives and firm performance.

The remainder of the paper is organized as follows. In Section 2, we present our model. In Section 3, we describe our data on incentives, firm performance, and board characteristcs. We present the econometric results in Section 4. Section 5 discusses the robustness of our findings. Section 6 concludes.

2. A Theory of Board Size

In this section, we present a theory of the size of the board of directors based on common agency (see Dixit (1996) and Bernheim and Whinston (1986)). The firm in our model is owned by a single shareholder who is the sole party that owns the rights to direct the firm's manager to undertake activities. However, he can share access to the manager by awarding contracting rights to other parties that may wish to direct the managers' activities. The shareholder may want to grant access to these other parties because he directly benefits from assets that they own and bring within the firm, if granted access. In our model, the shareholder and the other parties that are granted access to the manager then act like multiple principals (the members of the board) by contracting with a common agent (the manager) in a setting similar to the multi-task principal-agent model of Holmstrom and Milgrom (1991, 1987). Each director encourages the manager to pursue activities that he values, and discourages her from expending effort on tasks that the other director's value.

There exist a set of $\overline{N}$ activities corresponding to $\overline{N}$ parties that value them, that the firm can perform. The initial rights to the firm's assets are owned by a single party that we designate the shareholder, e, who only cares about one activity that maximizes firm value, as measured by the firm's stock price.[7] The other parties, $\overline{N}\backslash\{e\}$, care about other activities that this firm engages in. For example, an environmentalist cares about the extent to which a firm pollutes. A union representative cares about the working conditions at the firm. A member of the local

[7] For publicly traded companies, there also exist other shareholders (individual and institutional) who presumably care about the share price. We subsume these shareholders in the initial principal. We note, however, that initial shareholders may also care about things other than share price (e.g., they may view the firm as their legacy, etc.).

community or government cares about the location of production. We assume that these activities do not directly affect the shareholders' value. The parties other than the shareholder also own or control assets which are potentially valuable to the firm and the shareholder. For example, the environmentalist may have the ability to organize a boycott of the firm's products. The union representative may have the ability to launch a strike. Community members may be able to arrange tax relief for the firm. The value of party i's asset is A_i where for simplicity we assume that $A_i = A > 0, \forall i \in \overline{N} \backslash \{e\}$. We assume that these assets or the activities desired by the principals are noncontractible, i.e., the ownership of these assets is inalienable so the shareholder is unable to purchase them. Further, the shareholder cannot ex ante commit to deliver ex post the desired amount of an interested party's activity. Thus, the only way in which the shareholder can benefit from the assets owned by the other parties is by granting them access to contracting with the agent. In this case the parties bring their assets within the firm and the shareholder benefits from them.

Before contracting with the manager, the shareholder chooses the number of parties to grant access to the manager. Each party would like to influence the firm's activities (i.e., gain access to the manager) if the value of their asset is lower than the benefit they receive from directing the managers' activities. Under what conditions would the shareholder be willing to provide access to the manager for the other parties in exchange for their assets and under what conditions would the other parties be willing to part with their assets in exchange for access to directing the manager? The payoff (net of payment to the manager) to the shareholder from granting access to the $N-1$ other parties ($\{N-1\} \subset \overline{N} \backslash \{e\}$) in exchange for their $N-1$ assets is:[8]

$$\pi_e(N) = z_e(N) + (N-1)A,$$

where $\{N\} = \{N-1\} \cup \{e\}$ and $z_e(N)$ represents the net payoff to the shareholder from contracting with the manager. The payoff (net of payment to the manager) to party i ($i \in \{N-1\}$) from gaining access to the manager in exchange for party i's asset is:

$$\pi_i(N) = z_i(N) - A,$$

where $z_i(N)$ represents the net payoff to party i, $i = 1, ...N-1$, from contracting with the manager.

[8] Note that not every party that cares about the firm's activities will be granted access to the agent.

We seek the equilibrium number of parties N^* that will be granted access to the manager (the shareholder plus the $N-1$ other parties). An equilibrium board size N^* is described by:

(1) $\forall m < N^*, \pi_e(m) \leq \pi_e(N^*)$

(2) $\pi_i(N^*) \geq 0, i = 1, ...N^* - 1.$

The first condition implies that the shareholder grants access to the number of parties that maximize his value. The second condition implies that only parties that gain more than the value of their asset wish to get access to the manager. Collectively, the shareholder and the $N-1$ other parties that have access to the manager (N total) form the board of directors. If the shareholder grants access to no one, then $N = 1$, and only the shareholder has access to the manager. For $N > 1$, there are multiple board members who direct the managers' activities.

At time 1, the firm employs a manager to produce output. Once access to directing the manager's actions is granted, the shareholder and the $N-1$ other parties contract with the manager over the firm's activities. Given that there are N board members, there are N tasks or values that matter at the firm level. What we have in mind is that firms may care about values other than standard neoclassical shareholder value maximization. Firms may also care about employee satisfaction, environmental preservation, employee diversity, local community concerns, product quality, fairness of employment practices in foreign operations, and other possible issues. Of course, it may be the case that some of these values also impact shareholder value (e.g., product quality or liability), but these may also be values that matter to the firm independent of shareholder value maximization. We associate these N tasks with N directors who contract with the single manager performing these activities. Further, each task is associated with a single director, who solely cares about that task and is indifferent to the other $N-1$ tasks. We can relax this assumption quite easily without changing the character of our results.

At time 1, each director independently contracts with the manager in order to induce him to work on the task that the director cares about. For director i, $i \in N$, who cares about task i, the gross payoff from the manager taking action x_i is:

$$v_i = x_i + \varepsilon_i, \tag{1}$$

where $\varepsilon_i \sim N[0, \sigma_i^2]$ is a normally distributed shock to the performance measure v_i for task i. For simplicity, we assume that the variances of the N shocks are identical ($\sigma_i^2 = \sigma^2$ for all i) and that the N shocks are uncorrelated. These assumptions can also be relaxed while preserving our results.

We assume that the manager dislikes working in general, and working on multiple tasks in particular. The disutility from working on task i is given by $c_i x_i^2$ and the disutility from working on any pair of tasks i and j is given by $c_{ij} x_i x_j$. Here c_i and c_{ij} parameterize the cost of working on the tasks. For simplicity, we assume that $c_i = c_{ij} = c > 0$ for all i and j. This assumption can also be relaxed while preserving our results.

We assume that the manager is risk averse with coefficient of absolute risk aversion of r. We assume that the N directors are risk neutral. We restrict attention to linear contracts. Holmstrom and Milgrom (1987) show that linear contracts are equilibrium contracts in this setting, although there may also be nonlinear equilibrium contracts. Each director i offers the manager a contract of the form:

$$w_i = \beta_i + \sum_{j=1}^{N} \alpha_{ij} v_j. \tag{2}$$

So, the manager receives a fixed payment of β_i and performance related payments of $\alpha_{ij} v_j$ for all $j \in N$ tasks on which the manager may work. The expected net payoff to director i from contracting with the manager is:

$$z_i = E(v_i) - w_i = x_i - w_i,$$

which, as we shall see, will depend on the number of directors N. The manager's total compensation from the N directors is:

$$\begin{aligned} w &= \sum_{i=1}^{N} w_i \text{ where} \\ \beta &= \sum_{i=1}^{N} \beta_i \text{ and} \\ \alpha_j &= \sum_{i=1}^{N} \alpha_{ij}. \end{aligned} \tag{3}$$

The last statement says that for any task j, the aggregate incentives the manager has for that task are given by the sum of the incentives given by each director. Note that even though each director only cares about one task, each director will offer incentives on every task. For tasks that a director does not care about, these incentives will typically be negative in order to induce the manager to substitute away from working on those tasks.

We can now define the manager's aggregate certainty equivalent utility from contracting with the N directors as:

$$u=\beta+\sum_{j=1}^{N}\alpha_j x_j-c\sum_{j=1}^{N}x_j^2-\frac{c}{2}\sum_{j=1,j\neq k}^{N}\sum_{k=1}^{N}x_k x_j-\frac{r}{2}\sum_{j=1}^{N}\alpha_j^2\sigma^2. \tag{4}$$

At time 2, the manager maximizes this certainty equivalent over the N tasks and chooses an equilibrium activity level, x_i, for each task i. At time 3, outputs are realized and all payoffs are made. The following lemma describes the equilibrium contracts offered to the agent by the N directors.

Lemma 1 *In equilibrium, each director offers the manager a contract of:*

$$\begin{aligned}\alpha_{ii}^{*} &= \frac{cr\sigma^2\left(N^2-1\right)+1}{cr\sigma^2 N\left(N+1\right)+1}\ \textit{and} \\ \alpha_{ij}^{*} &= -\frac{cr\sigma^2\left(N+1\right)}{cr\sigma^2 N\left(N+1\right)+1}\ \textit{for all tasks } j\neq i.\end{aligned} \tag{5}$$

The manager's aggregate incentives for any task i are:

$$\alpha_i^{*}=\alpha_{ii}^{*}+(N-1)\alpha_{ij}^{*}=\frac{1}{cr\sigma^2 N\left(N+1\right)+1}. \tag{6}$$

Proof. *See Appendix.* ■

It follows that the manager's incentives for any task i are decreasing in the cost of performing tasks, c, the manager's risk aversion, r, and the variance of the performance measures, σ^2. These are standard results for the linear principal-agent model. More importantly, the manager's incentives for any task i are decreasing in the number of directors N. This is the comparative static we will focus on for this paper.

It is important to note that the number of principals matters in this common agency setting, above and beyond the number of tasks on which the agent works. While the agent also works on N tasks in this model, Holmstrom and Milgrom (1991) have show that the optimal contract for a setting in which a single principal contracts with an agent over N tasks would provide the agent with incentives for any task i of:

$$\alpha_i'=\frac{1}{cr\sigma^2\left(N+1\right)+1}. \tag{7}$$

Thus, the number of directors in common agency further mutes incentives relative to the number of tasks in the multitasking model.

Further, in equilibrium, the amount of task i taken by the manager as a function of number of directors is:

$$x_i^*(N) = \frac{1}{c^2 r\sigma^2 N\,(N+1)^2 + (N+1)c}$$

Consequently, director i's net payoff from contracting with the manager is:

$$z_i = x_i + \sum_{j=1}^{N}\sum_{k=1,k\neq i}^{N} \alpha_{kj}x_j - c\sum_{j=1}^{N} x_j^2 - \frac{c}{2}\sum_{j=1,j\neq k}^{N}\sum_{k=1}^{N} x_k x_j - \frac{r}{2}\sum_{j=1}^{N}\alpha_j^2\sigma^2,$$

which is decreasing and convex in the number of directors N.

Given the payoffs to the N director's, the equilibrium board size is obtained by maximizing the shareholder's profit, $\pi_e(N)$, subject to the participation constraints implied by the equilibrium conditions that describe the participation by other parties. So, the equilibrium is determined as the solution to the following program:

$$\arg\max_{N}\ \pi_e(N)$$
$$s.t.\ \ \pi_i(N^*) \geq 0, i = 1, ...N^* - 1$$

The following proposition establishes the existence of an equilibrium board size.

Proposition 2 *The equilibrium number of parties, including the shareholder, allowed access to contracting with the manager is* N^**, where*

1. $N^* = 1$*, if* $A > z_i(2)$ *or* $A < z_i(1) - z_i(2)$[9]
2. $1 < N^* < \infty$*, if* $A < z_i(2)$ *and* $A \geq z_i(1) - z_i(2)$.[10]

Proof. *If* $A > z_i(2)$ *then no outside party wishes to participate as the value of their asset is greater than the value to them of the manager performing any activity in addition to the one desired by the entrepreneur. If* $A < z_i(1) - z_i(2)$*, the entrepreneur's gain from an outside party's asset is smaller than the loss from providing them access to the manager, so he prefers to retain all rights to contracting with the agent.* $A < z_i(2)$ *and* $A \geq z_i(1) - z_i(2)$ *imply that the asset value for at least one party, other than the entrepreneur, is less than the value from the manager performing their task, and that the entrepreneur benefits from granting access to at least one other party. Further, since* $z_i(N) = z_e(N)$ *and* $z_i(N)$ *is monotonically decreasing in N, there exists an* $\widehat{n}$ *such that* $\pi_i(\widehat{n}) \geq 0$ *and* $\pi_i(m) < 0$ *for* $m > \widehat{n}$*.* ■

These results show that the shareholder either chooses to add no parties to the board of directors or chooses to keep adding parties to the board of directors until the reduction in incentives from adding more directors no longer makes it worthwhile for incremental parties to join the board. To see this, consider $A \geq z_i(1) - z_i(2)$. In this case, $A \geq z_i(m) - z_i(m+1)$,$\forall m > 1$, and the shareholder gains more from successively adding parties to the board of directors than he loses in

[9] *Alternatively,* $A < -z_i'(1)$.

[10] *Alternatively,* $A \geq -z_i'(1)$.

output. But since $z_i(m) - z_i(m+1) > 0$, $\exists\ \widetilde{n} > 1$ such that $\pi_i(\widetilde{n}) - \pi_i(\widetilde{n}+1) < A$, so additional parties choose not to join the board. Thus, what limits the size of the board of directors is the contracting friction induced by having multiple directors that reduce the gains from contracting with the manager. Thus the optimal board size is determined by the tradeoff between the value of the assets owned by outside parties and the value of the output produced by the manager.

Our model has several implications. In our model, directors differ only to the extent that they have different objectives and consequently the number of managerial objectives is increasing in the number of directors. Hence, the number of tasks performed by a firm is increasing in the number of directors on the board. Further, our model shows that managerial incentives, and consequently output, on every task is decreasing in the number of directors on a firm's board. These three implications form the basis of the hypotheses we test in the following sections of the paper.

3. Data

This section describes the data sources that we use to test our hypotheses. To examine whether board size is affected by firms' multiple objectives we construct a measure of firms' objectives (other than shareholder value maximization). We use data from KLD Research and Analytics, Inc. to construct our measure. KLD maintains the Socrates database that contains narrative coverage of firm performance along issues related to community, diversity, employee relations, environment, non-US operations, products, alcohol, tobacco, gambling, nuclear power and military contracting. The profiles also have social ratings evaluating each company's strengths and concerns in six categories, Community, Diversity, Employee Relations, Environment, Non-US operations and Product. Community strengths include charitable giving, support for housing, and support for education in the firm's local community. The Diversity category includes employment and promotion of women, minorities and the disabled, support for family benefits, and progressive policies for gays and lesbians. The Employee Relations category includes strong union relations, high employee involvement in profit sharing and management decision making, and strong retirement benefits. The Environment category includes firms' effort in reducing pollution, promoting recycling, providing environmentally friendly products and services, and using alternative fuels. The Non-US operations category includes charitable giving outside the US, respecting the sovereignty, land, culture, human rights, and intellectual property of indigenous peoples in other countries, and their community relations, employee relations or environmental impact outside the US. The Product category includes firms' commitment to high quality products, product innovation, and the provision of products or services for the economically disadvantaged. It is important to note that these objectives need not be incompatible with shareholder value maximization, but that they are not completely subsumed in shareholder value maximization either.

Using these data we construct a measure which reflects the diversity in firm objectives. Our measure is the firm's total number of strengths less the total number of concerns across all categories. This measure, which we call Objectives, ranges between -11 to 11. Table 1 contains descriptive statistics for our sample, beginning with Objectives. The mean and median for this measure is 0. If a firm has a high objectives score we interpret it as pursuing a greater number of non-share price goals, and if a firm has a negative Objectives score we take that to imply that the firm has various non-share price concerns but chooses not to pursue them.

The Socrates database has primary coverage for the S&P500 from 1991 to 2002. When we merge the Socrates data with our incentives and directors data (described below), we obtain a subsample of 2148 firm-year observations from 1998 to 2001. The remainder of Table 1 provides descriptive statistics for the board composition, incentives, and firm characteristic variables. Table 2 provides correlation coefficients for the variables used in our empirical analysis.

We use data on firm's boards of directors from firm proxy statements from 1998 to 2001. In our sample, the average board has 10.8 members. We also measure the strength of board monitoring through the fraction of independent directors. On average, 67% of the directors are independent directors–they are not affiliated with the firm except through their relationship as director.

We use Standard and Poor's ExecuComp dataset to construct our measure of managerial incentives. ExecuComp contains data on all aspects of pecuniary compensation for the top five executives (ranked annually by salary and bonus) at each of the firms in the S&P 500, S&P Midcap 400, and S&P SmallCap 600. In order to be consistent with our data on boards of directors, we measure incentives from 1998 to 2001. The ExecuComp data are collected directly from the companies' proxy statements and related filings with the Securities Exchange Commission. Our analysis in this paper uses data from the October 2002 release of the data (see Standard and Poor's

(1995) for further documentation). Financial and operating data for the ExecuComp sample companies are drawn from the Compustat dataset. Monthly measures of stock returns from the Center for Research on Security Prices (CRSP) are utilized in calculations of the variance of returns.

Managers can receive pay-performance incentives from a variety of sources. The vast majority of these incentives are due to ownership of stock and stock options (Jensen and Murphy (1990), Hall and Liebman (1998), Aggarwal and Samwick (1999, 2003b)). We use as our measure of incentives the pay-performance sensitivity, or "PPS," from holdings of stock and options. ExecuComp contains precise data on executives' holdings of stock in their own companies and grants of options during the current year. For stock, the pay-performance sensitivity is simply the fraction of the firm that the executive owns. A CEO who holds three percent of the stock outstanding in her firm will receive $30 per thousand dollar change in shareholder wealth. For options, the pay-performance sensitivity is the fraction of the firm's stock on which the options are written multiplied by the options' deltas.

For options granted in the current year, companies must report the number of options, the exercise price, and the exercise date. We assume the options will be exercised 70 percent through their term. The term structure of interest rates is obtained by interpolating the year-end Treasury yields for the one-, two-, three-, five-, seven-, ten-, and thirty-year constant maturity series. In applying the Black-Scholes formula, we use the dividend yield for the company reported by ExecuComp and calculate the standard deviation of monthly stock returns for each company using data from CRSP. We use up to five years of prior monthly returns to compute variances. We multiply this value by $\sqrt{12}$ to get the standard deviation of continuously compounded annual returns (volatility).

For options granted in previous years, the proxy statement reports only the aggregate number of securities and the aggregate "intrinsic value" of the options that are in the money. The intrinsic value of each option is the stock price at the end of the fiscal year less the option's exercise price–it corresponds to the value of the options if exercised immediately. Since the value of an option exceeds its intrinsic value, we estimate the value of options granted in prior years following the method of Murphy (1999). We treat all existing options as a single grant with a five year remaining term and an exercise price such that the intrinsic value of all options is equal to that reported on the proxy statement. Apart from having to impute the exercise price and years remaining until exercise, the methodology for options granted in previous years is the same as for current option grants.

To capture the notion of the agent from our model, we focus on the incentives to the top management team. The pay-performance sensitivity for the top management team is defined as the PPS for the CEO plus the PPS of the other executives at the firm whose information is reported in a given year. The average top management team has 5 members, consistent with the SEC reporting requirement. See Aggarwal and Samwick (2003a, c) for further discussion of the construction of these variables.

The mean top management team has a pay-performance sensitivity equal to 4.211 percent of the firm's equity. The interpretation of this number is that if the value of shareholder wealth increases by \$1000 over the course of a year, then the value of the stock and option holdings of the top management team will increase by \$42.11. The distribution of management incentives across firms is skewed to the right, with median incentives substantially lower at 1.925 percent.

We measure firm performance as Tobin's Q, which is calculated from Compustat. Tobin's Q is equal to the ratio of the sum of the market value of equity and the book value of debt to the book value of equity and book value of debt. Q is commonly used as a measure of firm performance (Morck, Shleifer, and Vishny (1988); McConnell and Servaes (1990); and Himmelberg, Hubbard, and Palia (1999)). Our calculation reflects average Q and abstracts from the effect of taxes on firm value. In our sample, the mean and median values of Q are 2.27 and 1.55, respectively.

The remainder of Table 1 presents the descriptive statistics for other variables that we control for in our econometric specifications for incentives and Q. We include the number of executives on the top management team as this number does not equal five for all observations. We include the dividend yield to control for payout policy. We include the natural log of sales to account for differences in firm size. We include the ratio of capital (net property, plant, and equipment) to sales to control for asset turnover. In the regressions presented below, we also include the squares of these two variables. We include the ratio of cash flow to capital as a measure of profitability. The effect of leverage is captured by the ratio of long-term debt to assets. We include the standard deviation of dollar returns to shareholders (calculated from CRSP, as described above) to allow for an effect of risk on incentives and firm value. Finally, we include controls for the ratio of research and development to capital and the number of different business segments reported by the firm. These last two variables are missing for several hundred observations. In the empirical work below, we set the values of these variables to zero for observations where they are missing and include a dummy variable for whether the data were originally missing. This procedure allows us to use all of the information that is provided about the variables of interest without reducing the sample size due to missing data on the control variables. These variables are essentially the same control variables used by Himmelberg, Hubbard, and Palia (1999) in their study of firm value and managerial ownership.

4. Empirical Results

Our model predicts relations between the number of firm objectives, number of principals (board size), managerial incentives, and firm performance. In particular, board size increases in firms' objectives, managerial incentives for any task will be decreasing in board size, whereas performance on a task will be increasing in incentives for that task. The particular performance measure we focus on is stock value, and hence incentives for this task will be given by stock-based pay-performance sensitivity. We perform three sets of tests. First, we examine the impact of firm level objectives on board size.[11] We then examine the effect of firm objectives and board size on pay-performance sensitivity. Finally, we examine the impact of firm objectives, board size, and pay-performance sensitivity on firm performance.

To examine whether board size is in fact related to multiple firm objectives, we estimate the following specifications:

$$Board_{it} = \beta_0 + \beta_1 OBJ_{it} + \sum_{k=1}^{K} \delta_k x_i^k + \mu_t + \tau_i + \varepsilon_i, \tag{8}$$

$$Ind_{it} = \beta_0 + \beta_1 Board_{it} + \beta_2 OBJ_{it} + \sum_{k=1}^{K} \delta_k x_i^k + \mu_t + \tau_i + \varepsilon_i, \tag{9}$$

[11] We note that there are many potential determinants of board size outside of our theory. For example, exchange listing requirements are such that boards must have a number of committees (e.g., an audit committee, a compensation committee, a nominating committee, etc.). These are in addition to other committees that a firm may choose to have (a strategy review committee, a diversity committee, etc.). The need to have sufficient board members to fill the exchange-required committees clearly falls outside of our theory, while having sufficient board members to fill the discretionary committees falls within our theory.

Board size is given by $Board_{it}$. As a robustness check, we also include a specification where the dependent variable is Ind_{it}, the fraction of independent directors on the board. Board independence has frequently been used as a proxy for board monitoring, and we want to ensure that our results are not simply being driven by the monitoring hypothesis. OBJ_{it} is the Objectives variable and the other covariates listed in Table 1 (excluding Tobin's Q, PPS, and the number of people in the top management team) are denoted by x_{it}^k. The specifications also include year effects denoted by μ_t and industry effects τ_i.

Table 3 contains the results. The first column has Board size as the dependent variable. The number of objectives is positively and significantly related to board size, and this relation is robust to the inclusion of the other covariates. Board size does appear to capture multiple firm objectives. The second column has the percentage of independent directors as the dependent variable. In this specification, we include board size as a control variable. In this specification, firm objectives are unrelated to the percentage of independent directors. These results suggest that board size does, in fact, capture features of multiple firm objectives although board independence does not.

Next we examine the effects of board size and multiple firm objectives on top management incentives. We estimate regressions of the following form:

$$PPS_{it} = \beta_0 + \beta_1 OBJ_{it} + \beta_2 Board_{it} + \beta_3 Ind_{it} + \sum_{k=1}^{K} \delta_k x_{it}^k + \mu_t + \varepsilon_{it} \tag{10}$$

In this equation, the dependent variable is PPS (stock-based incentives). The independent variables are OBJ_{it} (the number of firm objectives), $Board$ (board size), and Ind (the percentage of independent directors on the board). The other covariates (listed in Table 1) are denoted by x_{it}^k. The specification also includes year effects denoted by μ_t and industry effects τ_i.

The estimates of this specification are in Table 4. The first column includes board size, the percentage of independent directors, and the number of members of the top management team as independent variables. The coefficients for board size and the fraction of independent directors are estimated to be negative and significant. The finding that incentives are negatively related to the size of the board is consistent with Yermack (1996). To the extent that board size captures features of common agency, these results are consistent with our theory. The second column shows that firm objectives are not significantly related to top management incentives. The third column shows that, when the board size and board heterogeneity variables are included along with the firm objectives variable as well as the other covariates, the coefficients on board size and the percentage of independent directors remain negative and significant. To the extent that multiple tasks matters for incentives, it is solely through the effect of multiple tasks on multiple principals as captured by board size. Multiple objectives themselves are insignificant in the presence of multiple principals. This result suggests that multitasking in the absence of common agency does not explain our results.

Our third specification implies that increasing the size of the board of directors by one member is associated with a decrease in top management incentives of 0.364 percent. Given that average top management incentives are 4.211 percent, an increase in board size by one member is associated with a reduction in top management incentives by 8.64% of their aggregate amount. Further, suppose that the number of independent directors is increased by one person while holding the size of the board constant. The average board has 10.8 members in our sample, so a one-person increase in the number of independent directors corresponds to a 9.3% increase in the percentage of independent directors. A 9.3% increase in the percentage of independent directors is associated with a reduction in top management incentives of 0.911 percent. Given that average top management incentives are 4.211 percent, an increase in independent directors of one person holding board size constant is associated with a reduction in top management incentives by 21.64% of their aggregate amount. Changes in board size and independence are associated with economically meaningful changes in incentives. Further, the results for board size are consistent with common agency and the results for board independence are consistent with the monitoring hypothesis to the extent that monitoring and stock-based incentives are substitute mechanisms to induce effort.

The fourth column of Table 4 presents estimates of equation 10 while controlling for firm fixed effects. This specification controls for any time-invariant firm characteristics that could influence the relation between the board variables and top management incentives. The relations between the variables are estimated primarily by changes in the variables within firms over time. There are two concerns with fixed effects in this context. First, we have only four cross sections of data corresponding to the years 1998 to 2001 in our sample, perhaps limiting our ability to find meaningful variation. Second, our board variables are likely to evolve slowly over time, again limiting our ability to find meaningful within firm variation. Subject to these caveats, we find in column 4 that only board size is negatively and significantly (at the 5% level) associated with top management incentives. This result again supports the common agency explanation.

To examine the effect of board heterogeneity and managerial incentives on firm performance, we estimate the following regression:

$$Q_{it} = \beta_0 + \beta_1 PPS_{it} + \beta_2 Board_{it} + \beta_3 Ind_{it} + \beta_4 OBJ_{it} + \sum_{k=1}^{K} \delta_k x_{it}^k + \mu_t + \varepsilon_{it}. \qquad (11)$$

The dependent variable Tobin's Q is regressed on our measures of managerial incentives, PPS, board size, $Board$, proxy for monitoring, Ind, and objectives, OBJ. The regression also includes other covariates (listed in Table 1) denoted by x_{it}^k, and year effects denoted by μ_t. We estimate three specifications of equation 11. In the first specification (column 1 of Table 5), we regress Tobin's Q on objectives, board size, and the percentage of independent directors. Board size and independence are negatively and significantly related to firm performance, whereas the coefficient on objectives is positive and significant. This last result is somewhat surprising in that a greater number of objectives immediately implies that the firm is less focused on shareholder value. We discuss this result in greater detail below.

In the second column, we include the pay-performance sensitivity and size of the top management team, as well as the other covariates as control variables. The coefficient on managerial incentives is positive and significant. This result is consistent with Aggarwal and Samwick (2003a, c) who find that firm performance is positively related to managerial incentives.[12] The coefficient on objectives remains positive and significant, but has been reduced in magnitude. The coefficient on board size remains negative and significant, but has also been reduced in magnitude. The coefficient on the percentage of independent directors is now insignificant. The positive coefficient on managerial incentives and the negative coefficient on board size (in columns 1 and 2) are largely consistent with our theory.

To understand the surprising result that the number of objectives is positively related to firm performance, recall that when we endogenized the size of the board, we noted that only those

[12] Prior studies by Morck, Shleifer, and Vishny (1988); McConnell and Servaes (1990); and Himmelberg, Hubbard, and Palia (1999) have estimated the relationship between Q and incentives. These studies find either no relationship or a nonmonotonic relationship using earlier data. Aggarwal and Samwick (2003a, c) show that, for the sample used in this paper, the relationship between Q and incentives is positive. Furthermore, they find using a variety of piecewise-linear specifications of Q on incentives that they cannot reject the null hypothesis that the relationship between Q and incentives is the same over all ranges of incentives. Thus, they find that a linear specification is sufficient to examine the relationship between Q and incentives.

with valuable noncontractible assets in addition to other objectives would be permitted to join. When they join the board, their assets are contributed to the firm, and firm value increases by the contributed assets. At the same time, increasing the number of objectives increases contracting frictions and dissonance by increasing the size of the board. Thus there are two offsetting effects. In equation 11, contracting frictions due to common agency are captured by the size of the board and its associated impact on managerial incentives. As a result, an increase in objectives is left to capture the effect of more assets on firm value.

The third column estimates equation 11 while controlling for firm fixed effects. The caveats we noted earlier with regard to fixed effects are true here as well. In this specification, of the board variables, only board size remains marginally significant. Firm performance remains positively and significantly related to managerial incentives. These results may be affected, however, by the slow evolution of board characteristics through time. Nonetheless, these results are also consistent with the common agency theory.

There are three key findings. First, board size is increasing in the number of objectives, but board independence is not. Second, managerial incentives are negatively associated with both larger board size and greater board independence. Third, firm performance is negatively associated with larger board size and positively affected by managerial incentives. These three results are consistent with the theory.

5. Robustness

While the results described in the previous section are consistent with our theory, they are subject to several possible interpretations. Recall that the common agency theory posits that there are multiple principals with differing objectives. First, it may be the case that our board heterogeneity variable does not proxy for firm's multiple objectives in the sense that larger boards may not reflect greater heterogeneity of objectives but rather more directors focused on a single objective such as shareholder value maximization. However, we show in Table 3 that firms with larger boards have more objectives other than shareholder value maximization while directly controlling for other potential determinants of board size such as firm size, industry, capital structure, capital intensity, etc.

Second, the negative relation between incentives and our measure of multiple principals (board size) may only be capturing the effect of multiple objectives on incentives rather than the influence of multiple principals. However, Table 4 shows that the opposite is true. What matters for incentives is greater board size rather than more objectives. To the extent that objectives matter for incentives, it is through the effect of objectives on board size.

Third, one could argue that the size of the board does not capture board heterogeneity but rather reflects the intensity of board monitoring of the top management team since even though the percentage of independent directors may be smaller, the number of independent directors may be larger relatively to a smaller, more independent board (see Bhagat and Black, 2002). It is worth detailing why we believe the monitoring interpretation of what boards do does not fully explain these results. The monitoring story argues that a greater percentage of independent directors or a larger board implies that there is more monitoring of the top management team. As a result, incentives based on stock performance can be weaker. In this explanation, independent directors/larger boards and incentives are substitute mechanisms for addressing failures to maximize shareholder value. This is an alternative to our explanation that there are multiple principals with multiple objectives. The negative relation between incentives and the percentage of independent directors/larger boards we find in Table 4 seems to be consistent with this alternative hypothesis.

There are two reasons why we do not think the monitoring hypothesis is a full explanation for our results. First, the results from Table 5, Columns 2 and 3 show that firm performance is positively associated with incentives and negatively associated with the size of the board in the levels and changes specification. Table 5 also shows that there is no association between the percentage of independent directors and firm performance in either levels or changes once the other covariates are included. As noted before, this latter result may simply reflect the fact there is little variation in the percentage of independent directors, although our fixed effects results are consistent with the findings of Bhagat and Black (2002). In any event, the results in Table 5 do not support the monitoring hypothesis. Suppose that a firm experiences an exogenous shock that increases the likelihood that top management fails to maximize shareholder value. In this case, in equilibrium, one should observe increases in monitoring, increases in top management incentives, and decreases in firm performance. For the results in Table 5, this alternative hypothesis predicts that one should find negative coefficients on top management incentives and on the percentage of independent directors/board size. Instead, we find a positive coefficient on incentives, a negative coefficient on board size, and an insignificant coefficient on the percentage of independent directors in both columns 2 and 3.

Second, the negative relation between incentives and the percentage of independent directors/board size we find in Table 4 is not, in fact, consistent with the alternative hypothesis of board monitoring. The alternative hypothesis predicts that if there is an exogenous increase in the likelihood that top management fails to maximize shareholder value, then the use of all mechanisms to curtail this agency behavior will increase, even if the mechanisms are substitutes. As a result, there should be a positive relation between the percentage of independent directors/board size and top management incentives. This prediction is also rejected by the data. Last, while there are features of our results that are consistent with the monitoring hypothesis, we directly control for the extent of monitoring in all of our specifications by including board independence, which seems more likely to be tied to board monitoring than does board size per se.

Another possible interpretation of our results has to do with board capture. Several arguments have been made that the board does not optimally contract with the CEO and top management team but instead is captured by them, allowing management to set their own compensation and extract rents through incentives from the firm while the board acquiesces (see Bebchuk, Fried, and Walker (2002), Bertrand and Mullainathan (2001), and Shleifer and Vishny (1989)). This hypothesis is consistent with our finding that incentives are negatively related to board independence. If larger boards are less likely to be captured by management, then this argument would also be consistent with our finding that incentives are negatively related to board size. However, an implication of the board capture hypothesis is that rent extraction destroys firm value. As a result, greater incentives should be associated with lower firm performance and greater board independence and larger boards should be associated with higher firm performance. Neither of these predictions of the board capture hypothesis are borne out in our data. We find that greater incentives are associated with higher firm performance and that larger boards are associated with lower firm performance. These results cast doubt on the board capture hypothesis.

Another interpretation of our finding that larger boards are associated with lower firm value is that this is driven by free-rider problems at the board level and is not an outcome of common agency. The argument here is that, as a result of the fact that larger boards cannot coordinate on contracting or monitoring, firm performance suffers. The issue here is not that there are multiple objectives, but rather that there are too many board members to effectively coordinate. Lending support to this interpretation is the finding in Table 4 that it is board size that reduces incentives, not the number of objectives that the firm pursues. There are two reasons why this interpretation is not a full explanation for our results. First, Table 3 shows that objectives are positively related to board size. While a reverse causality argument might explain this (larger boards pursue more objectives independent of contracting, hence the results in Table 4), this leads to the second reason. Why are more objectives associated with better firm performance? One could argue that more successful firms can take on more objectives. Specifically, more successful firms grow, add more board members, pay their top executives more (higher pay-performance sensitivity), and start caring about other objectives because they have the luxury of doing so. But this then is difficult to reconcile with larger boards being associated with reduced firm performance.

Nevertheless, to address the potential endogeneity of board size and pay-performance sensitivity generally and reverse causality specifically, we perform a three-stage least squares estimation of the board size, incentives, and firm performance regressions. We estimate the following system of equations:

$$
\begin{aligned}
Board_{it} &= \beta_0 + \beta_1 Obj_{it} + \beta_2 LSales_{it} + \beta_3 LSales_{it}^2 + \beta_4 Seg_{it} + \beta_5 Segdum_{it} + \mu_t + \tau_i + \varepsilon_i \\
PPS_{it} &= \beta_0 + \beta_1 Board_{it} + \beta_2 Ind_{it} + \beta_3 Divyld_{it} + \beta_4 KS_{it} + \beta_5 KS_{it}^2 + \beta_6 Std_{it} + \mu_t + \tau_i + \varepsilon_i \\
Q_{it} &= \beta_0 + \beta_1 PPS_{it} + \beta_2 CFK_{it} + \beta_3 DA_{it} + \beta_4 RD_{it} + \beta_5 Rdum_{it} + \beta_6 Seg_{it} \\
&\quad + \beta_7 Segdum_{it} + \beta_8 Std_{it} + \mu_t + \tau_i + \varepsilon_i
\end{aligned}
\tag{12}
$$

Table 6 presents the three-stage least squares estimates of the structural equations. The results provide support for our primary hypotheses in that firm objectives are positively related to board size, board size is negatively related to pay-performance sensitivity, and pay-performance sensitivty is positively related to Q. Consequently, multiple firm objectives lower firm value by increasing the number of directors on firms' boards, which lowers managerial incentives. While we believe all of the alternative explanations have some merit, we do not view them as full explanations for our results.

6. Conclusion

In this paper, we study the effect of heterogeneity in firms' board of directors on managerial incentives and firm performance. We present a model of common agency, where a risk-averse agent performs multiple tasks for a firm that is owned by multiple principals who differ in the relative value they place on each task. We show that the agent's incentives, and consequently firm value, are lower than they would be had the contract been offered by a single principal. We test these predictions using data on managerial incentives from Standard and Poor's ExecuComp dataset, and data on board composition from firms' proxy statement disclosures filed with the Securities and Exchange Commission. We also supplement these data with firm performance data from Compustat and data on firm objectives other than shareholder value maximization from KLD Research and Analytics' Socrates database. Our empirical results are consistent with our model's predictions. Specifically, we find that board size is positively associated with objectives other than shareholder value maximization. Board size is negatively related to managerial incentives. Further, managerial incentives are positively related to firm performance and board size is negatively related to firm performance. Our results are robust to the inclusion of various board and firm control variables.

While our empirical results are consistent with the common agency model, we have only begun to scratch the surface of the model's implications for explaining board behavior. Our proxies for board heterogeneity are rather crude. While it is certainly plausible that greater board size reflects greater disagreement about firm objectives, it would be preferable to have direct measures of differences in board members' objectives. For example, European firms often have employee union representation on the board, bank or debtholder representation on the board, and in some cases, charitable foundation representation on the board. These data would provide a natural laboratory to further examine the importance of common agency for boards of directors. To the extent that we have been able to find results consistent with the theory in American data, where a priori we might have thought it to be unlikely to hold, this suggests that multiple objectives may in fact explain some of board behavior.

7. Appendix

The first order condition for any task j is:

$$\alpha_j = 2cx_j + c\sum_{k=1,k\neq j}^{N} x_k. \tag{13}$$

Solving all N first order conditions simultaneously, we get that the optimal action taken on task j is:

$$x_j = \frac{N\alpha_j - \sum_{k=1,k\neq j}^{N}\alpha_k}{(N+1)\,c}. \tag{14}$$

Here the $-\sum_{k=1,k\neq j}^{N}\alpha_k$ arises because any work done on task k detracts from work done on task j (due to the negative complementarity between all pairs of tasks) and α_k provides incentives to work on task k.

We can also define the incremental utility the agent gets from contracting with principal i relative to contracting with all of the other principals. We can write the aggregate contract without principal i as:

$$\begin{aligned} \beta^{-i} &= \sum_{k=1,k\neq i}^{N}\beta_k \text{ and} \\ \alpha_j^{-i} &= \sum_{k=1,k\neq i}^{N}\alpha_{kj}. \end{aligned} \tag{15}$$

We can also write the actions taken on the j tasks ($j \in N$) without contracting with principal i as $\left(x_j^{-i}\right)$ where:

$$x_j^{-i} = \frac{N\alpha_j^{-i} - \sum_{k=1,k\neq j}^{N}\alpha_k^{-i}}{(N+1)\,c}.$$

Then the incremental utility that the agent gets from contracting with principal i is:

$$\begin{aligned} u_i \;=\; & \beta + \sum_{j=1}^{N}\alpha_j x_j - c\sum_{j=1}^{N}x_j^2 - \frac{c}{2}\sum_{j=1,j\neq k}^{N}\sum_{k=1}^{N}x_k x_j - \frac{r}{2}\sum_{j=1}^{N}\alpha_j^2\sigma^2 \\ & -\beta^{-i} - \sum_{j=1}^{N}\alpha_j^{-i}x_j^{-i} + c\sum_{j=1}^{N}\left(x_j^{-i}\right)^2 + \frac{c}{2}\sum_{j=1,j\neq k}^{N}\sum_{k=1}^{N}x_k^{-i}x_j^{-i} + \frac{r}{2}\sum_{j=1}^{N}\left(\alpha_j^{-i}\right)^2\sigma^2. \end{aligned} \tag{16}$$

If principal i does not contract with the agent, then principal i receives in expectation:

$$x_i^{-i} = \frac{N\alpha_i^{-i} - \sum_{k=1,k\neq i}^{N}\alpha_i^{-i}}{(N+1)\,c} \tag{17}$$

because principal i only cares about task i. If principal i does contract with the agent, then principal i receives in expectation:

$$x_i - w_i = x_i - \beta_i - \sum_{j=1}^{N} \alpha_{ij} x_j. \tag{18}$$

Therefore the incremental utility principal i gets from contracting with the agent is:

$$x_i - w_i - x_i^{-i}. \tag{19}$$

We assume that there is a fixed participation constraint that the agent will be held to from her relationship with principal i:

$$u_i \geq \overline{u_i}. \tag{20}$$

This allows us to write the agent's wage from contracting with principal i as:

$$\begin{aligned} w_i &= \beta_i + \sum_{j=1}^{N} \alpha_{ij} x_j = -\sum_{j=1}^{N} \sum_{k=1,k\neq i}^{N} \alpha_{kj} x_j + c\sum_{j=1}^{N} x_j^2 + \frac{c}{2} \sum_{j=1,j\neq k}^{N} \sum_{k=1}^{N} x_k x_j + \frac{r}{2} \sum_{j=1}^{N} \alpha_j^2 \sigma^2 \qquad (21) \\ &\quad + \sum_{j=1}^{N} \alpha_j^{-i} x_j^{-i} - c\sum_{j=1}^{N} \left(x_j^{-i}\right)^2 - \frac{c}{2} \sum_{j=1,j\neq k}^{N} \sum_{k=1}^{N} x_k^{-i} x_j^{-i} - \frac{r}{2} \sum_{j=1}^{N} \left(\alpha_j^{-i}\right)^2 \sigma^2 + \overline{u_i} \end{aligned}$$

and principal i's incremental utility from contracting with the agent as:

$$\begin{aligned} x_i - w_i - x_i^{-i} &= x_i + \sum_{j=1}^{N} \sum_{k=1,k\neq i}^{N} \alpha_{kj} x_j - c\sum_{j=1}^{N} x_j^2 - \frac{c}{2} \sum_{j=1,j\neq k}^{N} \sum_{k=1}^{N} x_k x_j - \frac{r}{2} \sum_{j=1}^{N} \alpha_j^2 \sigma^2 \qquad (22) \\ &\quad - \sum_{j=1}^{N} \alpha_j^{-i} x_j^{-i} + c\sum_{j=1}^{N} \left(x_j^{-i}\right)^2 + \frac{c}{2} \sum_{j=1,j\neq k}^{N} \sum_{k=1}^{N} x_k^{-i} x_j^{-i} + \frac{r}{2} \sum_{j=1}^{N} \left(\alpha_j^{-i}\right)^2 \sigma^2 - \overline{u_i} - x_i^{-i} \end{aligned}$$

Holding every other principal's contract with the agent constant, we can solve for principal i's optimal contract. Before solving for the optimal contract, we note that, by definition, no term α_{ij} for all tasks j can appear in α_j^{-i}. Further, this implies that no term α_{ij} for all tasks j can appear in any expression x_j^{-i}. Therefore, we can ignore these terms in the optimization (i.e., all of the terms in the second line of the above equation). We also use the following derivatives to help us solve for the optimal contracts:

$$\begin{aligned} \frac{\partial x_i}{\partial \alpha_{ii}} &= \frac{N}{(N+1)\,c} \qquad (23) \\ \frac{\partial x_j}{\partial \alpha_{ii}} &= -\frac{1}{(N+1)\,c} \\ \frac{\partial x_i}{\partial \alpha_{ij}} &= -\frac{1}{(N+1)\,c} \\ \frac{\partial x_j}{\partial \alpha_{ij}} &= \frac{N}{(N+1)\,c} \end{aligned}$$

Taking the first order condition for equation 22 with respect to α_{ii} gives us:

$$\begin{aligned}
0 &= \frac{N}{(N+1)c} + \frac{N}{(N+1)c}\sum_{k=1,k\neq i}^{N}\alpha_{ki} - \frac{1}{(N+1)c}\sum_{j=1,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kj} \\
&\quad -\frac{2N}{(N+1)}x_i + \frac{2}{(N+1)}\sum_{j=1,j\neq i}^{N}x_j \\
&\quad -\frac{c}{2}\left[\frac{2N}{(N+1)c}\sum_{j=1,j\neq i}^{N}x_j - \frac{2(N-1)}{(N+1)c}x_i - \frac{1}{(N+1)c}\sum_{j=1,j\neq k,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}(x_k+x_j)\right] \\
&\quad -r\sum_{j=1}^{N}\alpha_{ji}\sigma^2 \qquad (24)\\
&= \frac{N}{(N+1)c} + \frac{N}{(N+1)c}\sum_{k=1,k\neq i}^{N}\alpha_{ki} - \frac{1}{(N+1)c}\sum_{j=1,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kj} - x_i \qquad (25)\\
&\quad +\frac{2-N}{(N+1)}\sum_{j=1,j\neq i}^{N}x_j + \frac{1}{2(N+1)}\sum_{j=1,j\neq k,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}(x_k+x_j) - r\sum_{j=1}^{N}\alpha_{ji}\sigma^2 \qquad (26)\\
&= \frac{N}{(N+1)c} + \frac{N}{(N+1)c}\sum_{k=1,k\neq i}^{N}\alpha_{ki} - \frac{1}{(N+1)c}\sum_{j=1,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kj} \qquad (27)\\
&\quad -x_i - r\sum_{j=1}^{N}\alpha_{ji}\sigma^2 \qquad (28)\\
&= \frac{N}{(N+1)c} + \frac{N}{(N+1)c}\sum_{k=1,k\neq i}^{N}\alpha_{ki} - \frac{1}{(N+1)c}\sum_{j=1,j\neq i}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kj} \qquad (29)\\
&\quad -\frac{N\alpha_i}{(N+1)c} + \frac{1}{(N+1)c}\sum_{k=1,k\neq i}^{N}\alpha_k - r\sum_{j=1}^{N}\alpha_{ji}\sigma^2 \qquad (30)\\
&= \frac{1}{(N+1)c}\left(N - N\alpha_{ii} + \sum_{k=1,k\neq i}^{N}\alpha_{ik} - r(N+1)c\sum_{j=1}^{N}\alpha_{ji}\sigma^2\right). \qquad (31)
\end{aligned}$$

It is straightforward to see that the second order condition is also satisfied. Taking the first order condition of equation 22 with respect to α_{ij} for $j \neq i$ gives us:

$$\begin{aligned} 0 &= -\frac{1}{(N+1)\,c} + \frac{N}{(N+1)\,c}\sum_{k=1,k\neq i}^{N}\alpha_{kj} - \frac{1}{(N+1)\,c}\sum_{l=1,l\neq j}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kl} && (32)\\ &\quad -\frac{2N}{(N+1)}x_j + \frac{2}{(N+1)}\sum_{l=1,l\neq j}^{N}x_l \\ &\quad -\frac{c}{2}\left[\frac{2N}{(N+1)\,c}\sum_{l=1,l\neq j}^{N}x_l - \frac{2\,(N-1)}{(N+1)\,c}x_j - \frac{1}{(N+1)\,c}\sum_{l=1,l\neq k,l\neq j}^{N}\sum_{k=1,k\neq j}^{N}(x_k+x_l)\right] \\ &\quad -r\sum_{i=1}^{N}\alpha_{ij}\sigma^2 \\ &= -\frac{1}{(N+1)\,c} + \frac{N}{(N+1)\,c}\sum_{k=1,k\neq i}^{N}\alpha_{kj} - \frac{1}{(N+1)\,c}\sum_{l=1,l\neq j}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kl} - x_j - r\sum_{i=1}^{N}\alpha_{ij}\sigma^2 && (33)\\ &= -\frac{1}{(N+1)\,c} + \frac{N}{(N+1)\,c}\sum_{k=1,k\neq i}^{N}\alpha_{kj} - \frac{1}{(N+1)\,c}\sum_{l=1,l\neq j}^{N}\sum_{k=1,k\neq i}^{N}\alpha_{kl} && (34)\\ &\quad -\frac{N\alpha_j}{(N+1)\,c} + \frac{\sum_{k=1,k\neq j}^{N}\alpha_k}{(N+1)\,c} - r\sum_{i=1}^{N}\alpha_{ij}\sigma^2 && (35)\\ &= \frac{1}{(N+1)\,c}\left(-1 - N\alpha_{ij} + \sum_{l=1,l\neq j}^{N}\alpha_{il} - r\,(N+1)\,c\sum_{i=1}^{N}\alpha_{ij}\sigma^2\right). && (36) \end{aligned}$$

The second order condition is also satisfied. Because the problem is symmetric for all N principals, there exists a set of symmetric equilibrium contracts. Principal i who cares about task i will offer incentives α_{ii} for that task. This α_{ii} will be symmetric for all principals $i \in N$. For all other tasks j, $j \neq i$, principal i will offer incentives of α_{ij}. Again, this will be symmetric for all principals $i \in N$ and tasks $j \in N$, $j \neq i$. This allows us to reduce N^2 first order conditions to 2 first order conditions by imposing symmetry. The first order conditions are:

$$0 = \frac{1}{(N+1)\,c}\left(N - N\alpha_{ii} + (N-1)\alpha_{ij} - cr\sigma^2\,(N+1)\,((N-1)\alpha_{ij} + \alpha_{ii})\right) \qquad (37)$$

and

$$0 = \frac{1}{(N+1)\,c}\left(-1 - N\alpha_{ij} + (N-2)\alpha_{ij} + \alpha_{ii} - cr\sigma^2\,(N+1)\,((N-1)\alpha_{ij} + \alpha_{ii})\right). \qquad (38)$$

Each principal offers the agent a contract of:

$$\begin{aligned} \alpha_{ii} &= \frac{cr\sigma^2\left(N^2-1\right)+1}{cr\sigma^2 N\,(N+1)+1} \text{ and} && (39)\\ \alpha_{ij} &= -\frac{cr\sigma^2\,(N+1)}{cr\sigma^2 N\,(N+1)+1} \text{ for all tasks } j \neq i. \end{aligned}$$

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Table 1
Descriptive Statistics for Variables Used in the Analysis

There are 2148 firm-year observations (842 firms) from 1998-2001.

Variable	Mean	Standard Deviation	1st Quartile	Median	3rd Quartile
Objectives	0.327	2.606	-1.000	0.000	2.000
Board Size	10.801	2.958	9.000	11.000	12.000
Independent Directors	66.207	16.875	55.556	69.231	80.000
Team PPS	4.211	6.517	0.921	1.925	4.309
Tobin's Q	2.273	2.119	1.172	1.554	2.499
Number in Team	5.146	0.792	5.000	5.000	5.000
Dividend Yield	1.562	1.561	0.045	1.267	2.377
Log(Sales)	8.160	1.311	7.229	8.187	9.059
Capital/Sales	0.452	0.582	0.138	0.242	0.484
Cash Flow/Capital	1.168	2.419	0.286	0.596	1.150
Debt/Assets	0.260	0.163	0.143	0.262	0.362
R&D/Capital	0.170	0.513	0.000	0.000	0.122
No. of Segments	1.905	1.525	1.000	2.000	3.000

Table 2
Descriptive Statistics for Variables Used in the Analysis

There are 2148 firm-year observations (842 firms) from 1998-2001. All cells contain Pearson correlations.

	LSIZE	IND	TPPS	Q	NUMT	DYLD	LSALE	KS	CFK	DA	STD	RDK	SEG
Objectives	0.014	0.011	0.032	0.112	0.004	-0.040	-0.111	-0.128	0.021	-0.151	-0.107	0.074	-0.118
Log of Board Size (LSIZE)		0.096	-0.244	-0.188	0.075	0.291	0.492	0.093	-0.008	0.190	0.255	-0.283	0.118
% Independent Directors (IND)			-0.324	-0.094	0.091	0.273	0.134	0.059	-0.039	0.099	0.045	-0.018	0.056
Team PPS (TPPS)				0.099	-0.072	-0.212	-0.241	-0.114	0.039	-0.186	-0.209	0.021	-0.092
Tobin's Q (Q)					-0.013	-0.286	-0.039	-0.165	0.087	-0.311	0.213	0.328	-0.111
Number in Team (NUMT)						0.016	0.092	0.033	0.018	0.055	0.103	0.031	0.050
Dividend Yield (DYLD)							0.088	0.205	-0.111	0.271	-0.176	-0.236	0.112
Log of Sales (LSALE)								-0.056	-0.006	0.168	0.649	-0.181	0.204
Capital/Sales ratio (KS)									-0.236	0.324	0.008	-0.147	0.046
Cash Flow/Capital Ratio (CFK)										-0.025	0.089	0.195	-0.103
Debt/Assets ratio (DA)											-0.001	-0.228	0.133
Std. dev. of CDF (STD)												0.114	0.027
R&D/Capital ratio (RDK)l													-0.073

Table 3
Effect of Firm Objectives on Board Size and Independence

Column 1 has the log of board size as the dependent variable and column 2 has the percentage of independent directors on the board of directors as the dependent variable. All regressions contain industry and year dummy variables and robust standard errors are reported in parentheses. 2148 firm-year observations in all regressions.

Variable	(1)	(2)
Constant	1.439	0.255
	(0.144)	(0.117)
Objectives	0.010	0.001
	(0.002)	(0.001)
Log(Board Size)		-0.022
		(0.017)
Dividend Yield	0.026	0.029
	(0.004)	(0.002)
Ln(Sales)	0.094	0.080
	(0.036)	(0.029)
$Ln(Sales)^2$	-0.001	-0.003
	(0.002)	(0.002)
Capital/Sales	0.045	0.021
	(0.020)	(0.015)
$(Capital/Sales)^2$	-0.006	-0.000
	(0.005)	(0.004)
Cash Flow/Capital	0.002	0.001
	(0.003)	(0.002)
Debt/Assets	-0.014	0.015
	(0.035)	(0.026)
CDF of Standard Deviation of Returns	0.055	-0.041
	(0.037)	(0.025)
R&D/Capital	-0.058	0.016
	(0.019)	(0.008)
Missing R&D/Capital	0.042	-0.010
	(0.013)	(0.009)
No. of Segments	0.024	0.004
	(0.004)	(0.003)
Missing Segments	0.151	0.035
	(0.019)	(0.012)
F-Statistics	41.83	9.22
Adjusted R^2	0.399	0.121

Table 4
Effect of Board Size on Pay- Performance Sensitivity

The dependent variable is the pay-performance sensitivity for the top management team. 2148 firm-year observations. Industry and year-dummies are included in all specifications, but not reported. Robust standard errors in parentheses.

Variable	(1)	(2)	(3)	(4)
Constant	25.105	21.315	27.930	8.596
	(2.113)	(5.912)	(5.311)	(11.617)
Objectives		-0.053	-0.002	-0.034
		(0.042)	(0.040)	(0.065)
Log(Board Size)	-5.104		-3.637	-1.339
	(0.549)		(0.812)	(0.690)
Percentage Independent Directors	-11.621		-9.841	-1.527
	(0.960)		(0.919)	(0.918)
Number in Team	-0.242	-0.209	-0.031	0.554
	(0.289)	(0.285)	(0.275)	(0.103)
Dividend Yield		-0.893	-0.524	0.006
		(0.089)	(0.088)	(0.110)
Ln(Sales)		-1.566	-0.462	-0.596
		(1.453)	(1.439)	(2.644)
$Ln(Sales)^2$		0.059	0.022	-0.015
		(0.081)	(0.080)	(0.154)
Capital/Sales		-1.761	-1.413	-0.569
		(0.564)	(0.519)	(0.971)
$(Capital/Sales)^2$		0.372	0.351	0.086
		(0.168)	(0.148)	(0.172)
Cash Flow/Capital		0.002	0.019	0.006
		(0.064)	(0.061)	(0.069)
Debt/Assets		-4.492	-4.426	1.340
		(1.005)	(0.977)	(1.195)
CDF of Standard Deviation of Returns		-5.094	-5.353	-0.765
		(1.379)	(1.325)	(1.857)
R&D/Capital		-0.457	-0.507	-0.085
		(0.258)	(0.258)	(0.673)
Missing R&D/Capital		0.300	0.360	-0.313
		(0.502)	(0.486)	(0.862)
No. of Segments		0.293	0.153	0.054
		(0.117)	(0.113)	(0.126)
Missing Segments		0.223	1.086	0.642
		(0.544)	(0.573)	(0.457)
F-Statistics	128.12	11.67	16.94	18.27
Adjusted R^2	0.151	0.152	0.220	0.909

Table 5
Effect of Board Size and Pay- Performance Sensitivity on Q

The dependent variable is Tobin's Q in all specifications. 2148 firm-year observations. Industry and year-dummies are included in all specifications, but not reported. Robust standard errors in parentheses.

Variable	(1)	(2)	(3)
Constant	6.198	7.903	5.393
	(0.579)	(1.493)	(5.379)
Pay-Performance Sensitivity		0.018	0.024
		(0.008)	(0.012)
Objectives	0.094	0.046	-0.003
	(0.014)	(0.014)	(0.030)
Log(Board Size)	-1.413	-0.569	-0.601
	(0.195)	(0.189)	(0.322)
Percentage Independent Directors	-0.973	-0.263	-0.480
	(0.246)	(0.281)	(0.426)
Number in Team		-0.076	-0.033
		(0.044)	(0.048)
Dividend Yield		-0.051	0.006
		(0.019)	(0.051)
Ln(Sales)		-1.156	-0.014
		(0.338)	(1.224)
$Ln(Sales)^2$		0.064	-0.026
		(0.018)	(0.071)
Capital/Sales		-0.086	-1.669
		(0.132)	(0.449)
$(Capital/Sales)^2$		-0.005	0.209
		(0.024)	(0.079)
Cash Flow/Capital		0.032	0.126
		(0.027)	(0.032)
Debt/Assets		-2.323	-1.159
		(0.281)	(0.552)
CDF of Standard Deviation of Returns		2.779	-1.446
		(0.366)	(0.859)
R&D/Capital		0.497	1.878
		(0.292)	(0.312)
Missing R&D/Capital		-0.363	0.155
		(0.089)	(0.399)
No. of Segments		-0.177	0.034
		(0.026)	(0.058)
Missing Segments		-0.855	0.043
		(0.107)	(0.212)
F-Statistics	41.11	24.05	6.00
Adjusted R^2	0.053	0.295	0.810

Table 6
Three-Stage Least Squares Estimates of the Relation between Board Size, Pay- Performance Sensitivity and Q

2148 firm-year observations. Industry and year-dummies are included in all specifications, but not reported.

Variable	Log(Board Size)	PPS	Q
Constant	1.397 (0.136)	7.419 (0.379)	1.568 (0.364)
Objectives	0.010 (0.002)		
Log(Board Size)		-1.834 (0.184)	
Percentage Independent Directors		-1.565 (0.118)	
Pay-Performance Sensitivity			0.289 (0.066)
Number in Team		0.072 (0.024)	-0.097 (0.050)
Dividend Yield		-0.209 (0.017)	
Ln(Sales)	0.126 (0.033)		
$Ln(Sales)^2$	-0.002 (0.002)		
Capital/Sales		-0.675 (0.072)	
$(Capital/Sales)^2$		0.131 (0.022)	
Cash Flow/Capital			0.032 (0.017)
Debt/Assets			-2.599 (0.262)
CDF of Standard Deviation of Returns		-1.262 (0.118)	2.379 (0.223)
R&D/Capital			0.597 (0.086)
Missing R&D/Capital			-0.381 (0.106)
No. of Segments	0.032 (0.004)		-0.194 (0.033)
Missing Segments	0.175 (0.016)		-0.869 (0.139)
System weighted R^2		0.407	